4 Risk Assessment Data Reduction Rules

General data reduction rules for the tissue and sediment chemistry data collected in 2009 and 2010 have been established. These rules will be applied, as appropriate, to data that will be used in the risk assessments to determine EPCs. The data reduction rules and additional rules for data reduction that are specific to the risk assessments are summarized in the following subsections.

4.1 CALCULATED TOTALS

Multiple totals will be presented in the LPRSA database based on multiple methods for treating RLs. However, for the risk assessments, only one total (derived using Rules 1 and 2, as appropriate) will be used in deriving risk estimates. Totals based on the following rules will be used for evaluation in the risk assessments:

- **Rule 1 (for non-toxicity-weighted totals)** – The total used in the risk assessments will be based on the sum of the detected constituent parameters (non-detected parameters will be treated as zeros); if none of the constituent parameters are detected, the total concentration will be flagged as non-detected (U-qualified) and represented as the highest RL. If any one of the constituent parameters is not reported, partial totals will be calculated and flagged. The use of partial totals will be addressed in the uncertainty analysis in the risk assessments.

  In order to ensure that the rule for determining non-toxicity-weighted totals is appropriate in the risk assessments, exposure estimates using totals based on the treatment of non-detects as zero, one-half the RL, and equal to the RL will be compared with one another to determine whether the treatment of non-detected parameters (as zero) affects exposure estimates. This evaluation will be included in the discussion of uncertainties associated with risk estimates.

- **Rule 2 (for toxicity-weighted totals)** – The toxicity-weighted total used in the risk assessments will be based on the sum of the detected constituent parameters multiplied by their respective TEFs (non-detected parameters will be treated as zeros). If none of the constituent parameters within the toxicity-weighted total are detected, the total will be flagged as non-detected (U-qualified) and the TEQ value will be the highest toxicity-weighted reporting limit. If any one of the constituent parameters is not reported, partial totals will be calculated and flagged. The TEFs used to calculate TEQs for polychlorinated dibenzo-*p*-dioxins/ polychlorinated dibenzofurans (PCDDs/PCDFs) and dioxin-like PCB congeners for use in the BERA will be the World Health Organization (WHO) consensus values for fish and birds from Van den Berg et al. (1998). For the HHRA, the updated USEPA mammalian TEFs (USEPA 2010c) will be used to calculate TEQs. Carcinogenic PAH values will be calculated

using TEF values (USEPA 1993b) based on the individual PAH component's toxicity relative to benzo(a)pyrene.

In order to ensure that the rule for determining toxicity-weighted totals is appropriate in the risk assessments, exposure estimates using totals based on treatment of non-detects as zero, one-half the RL, and equal to the RL will be compared with one another to determine whether the treatment of non-detected parameters (as zero) affects exposure estimates. This evaluation will be included in the discussion of uncertainties associated with risk estimates.

Table 4-1 presents the constituent parameters for summations and risk assessment summation rules for LPRSA risk assessment data. The constituent parameters to be included in totals will be applied to all data that meet the acceptability criteria for use in developing risk estimates. The constituent parameters included in sums are consistent with the summations described in the *Fish/Decapod Crustacean Tissue and Benthic Sediment Data Management Plan* (ddms, in prep).

Table 4-1. Constituent parameters and risk assessment summation rules for LPRSA data

Parameter	Constituent Parameters	Risk Assessment Rule[a]
PCBs		
Total PCB congeners[b]	209 PCB congeners	Rule 1
Total PCB Aroclors[b]	Aroclor 1016, Aroclor 1221, Aroclor 1232, Aroclor 1242, Aroclor 1248, Aroclor 1254, Aroclor 1260, Aroclor 1262, and Aroclor 1268	Rule 1
PAHs		
Total HPAHs	benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene,[c] benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3,-c,d)pyrene, and pyrene	Rule 1
Total LPAHs	acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, and phenanthrene	Rule 1
Total PAHs	acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene,[c] benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3,-c,d)pyrene, naphthalene, phenanthrene, and pyrene	Rule 1
Total benzofluoranthenes	benzo(b)fluoranthene,[c] benzo(k)fluoranthene	Rule 1
Carcinogenic PAHs	benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenz(a,h)anthracene, indeno (1,2,3-cd)pyrene, chrysene	Rule 2
Pesticides		
Total chlordanes	alpha-chlordane, gamma-chlordane, oxychlordane, cis-nonachlor, and trans-nonachlor	Rule 1
Total endosulfan	alpha-endosulfan (endosulfan I), beta-endosulfan (endosulfan II), and endosulfan sulfate	Rule 1

Table 4-1. Constituent parameters and risk assessment summation rules for LPRSA data

Parameter	Constituent Parameters	Risk Assessment Rule[a]
Total 4,4'-DDx	4,4'-DDD; 4,4'-DDE; 4,4'-DDT	Rule 1
Total 2,4'- and 4,4'-DDD	2,4'-DDD; 4,4'-DDD	Rule 1
Total 2,4'- and 4,4'-DDE	2,4'-DDE; 4,4'-DDE	Rule 1
Total 2,4'- and 4,4'-DDT	2,4'-DDT; 4,4'-DDT	Rule 1
Total DDx	2,4'-DDD; 2,4'-DDE; 2,4'-DDT; 4,4'-DDD; 4,4'-DDE; 4,4'-DDT	Rule 1
TEQ		
Total TEQ – mammal	Seventeen 2,3,7,8-substituted PCDD/PCDF congeners and twelve dioxin-like PCB congeners[d]	Rule 2
Total TEQ – bird	Seventeen 2,3,7,8-substituted PCDD/PCDF congeners and twelve dioxin-like PCB congeners[d]	Rule 2
Total TEQ – fish	Seventeen 2,3,7,8-substituted PCDD/PCDF congeners and twelve dioxin-like PCB congeners[d]	Rule 2

[a] Rule 1 – Use the sum of the detected constituent parameters only; non-detects will be treated as zeros. An evaluation will be conducted to determine whether the treatment of non-detected parameters (as zero) for non-toxicity-weighted totals affects exposure estimates by comparing sums based on treatment of non-detects as zero, one-half of the RL, and equal to the RL in the uncertainty sections of the risk assessments.

Rule 2 – Use the sum of the concentration of each congener after multiplying by its corresponding TEF value. When the congener concentration is reported as non-detected, then multiply the TEF by zero. An evaluation will be conducted to determine whether the treatment of non-detected parameters (as zero) for toxicity-weighted totals affects exposure estimates by comparing sums based on treatment of non-detects as zero, one-half of the RL, and equal to the RL in the uncertainty sections of the risk assessments.

[b] For the risk assessments, total PCBs will be based on total PCB congeners (if available) or total PCB Aroclors (if PCB congener data are not available and total PCB Aroclors is deemed representative). When calculating a PCB congener sum, the concentration associated with a given co-elution will be included in the sum once.

[c] Benzo(j)fluoranthene, benzo(b/j)fluoranthene, and benzo(j/k)fluoranthene will also be included in the HPAH, total PAH, and total benzofluoranthene totals when reported.

[d] The twelve dioxin-like congeners are: PCB 77, PCB 81, PCB 105, PCB 114, PCB 118, PCB 123, PCB 126, PCB 156, PCB 157, PCB 167, PCB 169, and PCB 189.

DDD – dichlorodiphenyldichloroethane
DDE – dichlorodiphenyldichloroethylene
DDT – dichlorodiphenyltrichloroethane
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
LPRSA – Lower Passaic River Study Area
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
PCDD – polychlorinated dibenzo-*p*-dioxin
PCDF – polychlorinated dibenzofuran
RL – reporting limit
TEF – toxic equivalency factor
TEQ – toxic equivalent
Total 4,4'-DDx – sum of 4,4'- substituted DDD, DDE and DDT
Total DDx – sum of all six DDT isomers (2,4′-DDD, 4,4-DDD, 2,4′-DDE, 4,4-DDE, 2,4′-DDT and 4,4′-DDT)

4.2 SELECTION OF SINGLE RESULT WHERE MULTIPLE RESULTS ARE REPORTED

In cases where multiple results are reported for a given sample, the risk assessments will use only one value so that every sample will be associated with one result per analyte. The rules for selecting the most appropriate result will be applied to all data

that will be used in the risk assessments. The following subsections present the two cases wherein CPG will select a single sample result for use in the risk assessment: when multiple analytical methods are used for the analysis of the same chemical in a single sample (Section 4.2.1), and when multiple results are available due to QC analyses (Section 4.2.2).

4.2.1 Multiple analytical results for single sample

Multiple validated results for a given sample may be reported for specific analytes. When multiple results are reported for a single parameter, the most appropriate result will be flagged for reporting, analysis, and parameter summing, according to the best result selection rules for the LPRSA 2009 and 2010 CPG-collected data as described in the *Fish/Decapod Crustacean Tissue and Benthic Sediment Data Management Plan* (ddms, in prep):

- Analyte overlap will occur in the SVOC and PAH groups, and the high-resolution results will take precedence over the low-resolution results (e.g., gas chromatography (HRGC)/high-resolution mass spectrometry [HRMS], HRGC/low-resolution mass spectrometry-selective ion monitoring [SIM], and GC/MS-SIM results will take precedence over the low-resolution results [GC/MS]).
- Analyte overlap will occur in the SVOC and organochlorine pesticide groups (e.g., hexachlorobenzene). The HRGC/HRMS organochlorine results will take precedence over the SVOC results.

The selected best result (which is flagged) will be used in the risk assessments; unflagged result(s) will not be used.

4.2.2 Field duplicates and laboratory replicates

Field duplicates and/or laboratory QC analytical samples may result in more than one analytical result for field-collected samples. QC samples will be evaluated as part of the data validation process to ensure that QA/QC criteria are met. If QC samples are analyzed for a given field sample, only one value will be used in the LPRSA database.

Field duplicate results will be averaged with the parent sample result using the following rules:

- If both values are detected, the results will be averaged to determine a single result for inclusion in the LPRSA database.
- If a constituent is detected in only one sample, the detected value will be used.
- If a constituent is not detected in either sample, the result will be flagged as a non-detect (U-qualified), and the average of the two RLs will be used in the LPRSA database.

Lab replicate results will not be used in the LPRSA database; the value reported with the field sample will be used.

For reconstituted whole-body concentrations that include a non-detected value for at least one tissue type, the non-detected value(s) will be represented in the calculation by one-half the detection limit. In cases where both tissue types are non-detected values, the final reconstituted whole-body result will be flagged as a non-detected result (U-qualified). The uncertainties associated with this assumption (i.e., the treatment of non-detected concentrations in reconstituting whole-body tissue concentrations) and the implications of using these data in the risk assessments will be evaluated and included in the uncertainty analysis of the risk assessments.

5.3 TREATMENT OF NON-DETECTS IN RISK CALCULATIONS

In the risk assessments, estimates of exposure will be based on an upper bound measure of central tendency identified as the UCL concentration. UCL concentrations will be calculated using ProUCL 4.1.00 (USEPA 2010a).[7] Because ProUCL 4.1.00 includes provisions for handling non-detected data (USEPA 2010b), all data (detected and non-detected) will be used. For datasets of 5 to 10 samples, as agreed with USEPA, the UCL recommended by ProUCL will be used if it is below the maximum, and these instances will be identified in the text of the risk assessment. Details on how exposures will be estimated, including the statistics that will be used to represent the EPCs, are described in the Revised RARC Plan (Windward and AECOM [in prep]). The sensitivity of the treatment of non-detects will be evaluated in the uncertainty sections of risk assessments.

5.4 SIGNIFICANT FIGURES

Analytical laboratories will report results with various numbers of significant figures depending on the laboratory's SOPs, the instrument, chemical, and the reported chemical concentration relative to the RL. The reported (or assessed) precision of each result will be explicitly stored in the risk assessment database by recording the number of significant figures. Tracking of significant figures is important when calculating averages and performing other data summaries. The appropriate number of significant figures associated with specific risk estimates will be applied in the last step of each calculation, and will reflect the least precise value in the calculation (i.e., the lowest number of significant figures). Human health risks will be reported using one significant figure, consistent with USEPA Risk Assessment Guidance for Superfund, Part A (USEPA 1989).

[7] When ProUCL 5.0.00 was made available in September 2013, most of the risk assessment evaluations were already in process, exceptions include background data and sediment data for river segments for the HHRA; in these cases, ProUCL (5.0.00) will be used for the UCL calculations.

Table 6-30. Surface water HQs for benthic invertebrates based on uncertainties in EPCs

Uncertainty	Parameter Values/Assumptions		UCL HQ					
			Benzo(a)anthracene		Benzo(a)pyrene		Total PCBs	
	Original	Adjusted	Original	Adjusted	Original	Adjusted	Original	Adjusted
Freshwater (RM 8 to RM 17.4)								
EPC as total concentration	EPC based on whole-water total concentration	EPC based on estimated dissolved concentration	**3.2**	< 0.01	**6.7**	< 0.01	0.15	ne[a]
Treatment of non-detects	DL = 0 for non-detects	use of one-half the DL or the full DL for non-detects[b]		na		na		0.15
Estuarine (RM 0 to RM 8)								
Treatment of non-detects	DL = 0 for non-detects	use of one-half the DL or the full DL for non-detects[b]	na	na	na	na	0.21	0.21 – 0.22

[a] The effect on HQs for nonionic organic COPECs other than benzo(a)anthracene and benzo(a)pyrene was not evaluated because HQs were < 1.0 based on the whole-water sample results, and dissolved concentrations are expected to be lower than whole-water sample concentrations.

[b] LOAEL HQs are the same, except where a range is presented, regardless of treatment of non-detected values as one-half the DL or as the full DL

COPEC – chemical of potential ecological concern
DL – detection limit
EPC – exposure point concentration
HQ – hazard quotient
LOAEL – lowest-observed-adverse-effect level
na – not applicable
ne – not evaluated
RM – river mile
PCB – polychlorinated biphenyl
UCL – upper confidence limit on the mean

Bold identifies HQs > 1.0.

Table 7-10. Fish tissue HQs based on uncertainties in exposure assumptions and EPCs

Uncertainty	Parameter Values/Assumptions		LOAEL HQ					
			Total PCBs		PCDD/PCDF TEQ		Total TEQ	
	Original	Adjusted	Original	Adjusted	Original	Adjusted	Original	Adjusted
Benthic Omnivore (mummichog, other forage fish)								
Treatment of non-detects	DL = 0 for non-detects	use of one-half the DL or the full DL for non-detects[a]	0.10 – 0.13	0.10 – 0.13	0.33 – 0.52	0.33 – 0.52	0.35 – 0.52	0.35 – 0.52
		use of Kaplan-Meier method in USEPA's TEQ calculator (USEPA 2014)		na		0.33 – 0.52		0.33 – 0.52
Invertivore (white perch, channel catfish, brown bullhead)								
Treatment of non-detects	DL = 0 for non-detects	use of one-half the DL or the full DL for non-detects[a]	0.22 – 0.41	0.22 – 0.41	0.65 – **1.4**	0.65 – **1.4**	0.72 – **1.1**	0.72 – **1.1**
		use of Kaplan-Meier method in USEPA's TEQ calculator (USEPA 2014)		na		0.65 – **1.4**		0.65 – **1.4**
Piscivore (American eel, largemouth bass)								
Treatment of non-detects	DL = 0 for non-detects	use of one-half the DL or the full DL for non-detects[a]	0.32 – **1.3**	0.32 – **1.3**	0.16 – **1.2**	0.16 – **1.2**	0.22 – **1.2**	0.22 – **1.2**
		use of Kaplan-Meier method in USEPA's TEQ calculator (USEPA 2014)		na		0.16 – **1.2**		0.17 – **1.2**

[a] LOAEL HQs are the same, regardless of treatment of non-detected values as one-half the DL or as the full DL.

DL – detection limit
EPC – exposure point concentration
HQ – hazard quotient
LOAEL – lowest-observed-adverse-effect level
na – not applicable
PCDD – polychlorinated dibenzo-*p*-dioxin
PCDF – polychlorinated dibenzofuran
RM – river mile
TEQ – toxic equivalent
USEPA – US Environmental Protection Agency

Bold identifies HQs > 1.0.

Table 7-26. Surface water HQs for fish based on uncertainties in EPCs

Uncertainty	Parameter Values/ Assumptions		UCL HQ					
			Benzo(a)anthracene		Benzo(a)pyrene		Total PCBs	
	Original	Adjusted	Original	Adjusted	Original	Adjusted	Original	Adjusted
Freshwater (RM 8 to RM 17.4)								
Use of EPC as total concentration	EPC based on whole-water total concentration	EPC based on estimated dissolved concentration	**2.3**	< 0.01	**4.8**	< 0.01	0.15	ne[a]
Treatment of non-detects	DL = 0 for non-detects	use of one-half the DL or the full DL for non-detects[b]		na		na		0.15
Estuarine (RM 0 to RM 8)								
Treatment of non-detects	DL = 0 for non-detects	use of one-half the DL or the full DL for non-detects[b]	na	na	na	na	0.19	0.19

[a] The effect on HQs for nonionic organic COPECs other than benzo(a)anthracene and benzo(a)pyrene was not evaluated because HQs were < 1.0 based on the whole-water sample results and dissolved concentrations are expected to be lower than whole-water sample concentrations.

[b] HQs are the same, regardless of treatment of non-detected values as one-half the DL or as the full DL

COPEC – chemical of potential ecological concern
DL – detection limit
EPC – exposure point concentration
HQ – hazard quotient
na – not applicable
ne – not evaluated
PCB – polychlorinated biphenyl
RM – river mile
UCL – upper confidence limit on the mean

Bold identifies HQs > 1.0.

7.3.4.3 Comparison to background

Surface water data from individual samples collected at one background location above Dundee Dam were compared to concentrations of COPECs in LPRSA surface water from RM 0 to RM 17.4 for the five COPECs with HQs > 1.0. An estuarine background location was not selected for surface water, so all LPRSA surface water was compared to the single freshwater location above Dundee Dam. Due to the limitations of a small background dataset, the cumulative frequency of LPRSA freshwater and estuarine data were ranked relative to the freshwater background data.

Approximately half of LPRSA samples exceeded the highest background concentrations of benzo(a)anthracene and benzo(a)pyrene (Figures 7-7 and 7-8). Cyanide was not detected in any of the background samples (DL was 0.01 mg/L). Only one of the seven samples in which cyanide was detected had a concentration (0.031 mg/L) greater than the background DL.

resulted in a substantial change to the HQs: the total TEQ HQ decreased from 1.2 to 0.076 (Table 7-30).

Table 7-30. Fish egg HQs based on uncertainties in EPCs and TRVs

Uncertainty	Parameter Values/Assumptions		LOAEL HQ			
			Total PCBs		Total TEQ	
	Original	Adjusted	Original	Adjusted	Original	Adjusted
Mummichog						
Treatment of non-detects	DL = 0 for non-detects	DL = one-half the DL or full DL for non-detects[a]	**2.2**	**2.2**	**1.2**	**1.2**
Use of species-specific TRV	LOAEL based on SSD that includes species with higher sensitivity than great blue heron	LOAEL based on mummichog toxicity data		na		0.076

[a] LOAEL HQs are the same, regardless of treatment of non-detected values as one-half the DL or as the full DL.

DL – detection limit
EPC – exposure point concentration
HQ – hazard quotient
LOAEL – lowest-observed-adverse-effect level
na – not applicable
PCB – polychlorinated biphenyl
RM – river mile
SSD – species sensitivity distribution
TEQ – toxic equivalent
TRV – toxicity reference value
USEPA – US Environmental Protection Agency

Bold identifies HQs > 1.0.

7.4.4.3 Comparison to background

As described in Section 7.1.4.2, HQs based on background concentrations for receptor-COPEC pairs with LOAEL HQs > 1.0 were derived. Three background datasets were developed for use in the BERA using available data from the following areas: 1) data from upstream of Dundee Dam, to represent freshwater urban habitat, 2) data from Jamaica Bay / Lower Harbor, to represent estuarine urban habitat, and 3) data from Mullica River / Great Bay, to represent estuarine / freshwater rural habitat. These datasets are summarized in Section 4.2, and details on how background values were determined from these datasets are presented in Appendix J. Background HQs are presented in Table 7-31.

Table 7-31. Comparison of LPRSA fish egg tissue HQs with background HQs

COPEC	LOAEL HQ			
	LPRSA[a]	Above Dundee Dam[b]	Jamaica Bay/ Lower Harbor[c]	Mullica River/ Great Bay[d]
Total PCBs	**2.2**	0.56	**13**	0.54[e]
PCDD/PCDF TEQ	**1.2**	0.0068	0.26	0.0040
Total TEQ	**1.2**	0.024	0.58	0.0043

[a] Based on UCL concentration of mummichog (n = 26) collected from the LPRSA.

Table 8-13. Bird dietary HQs based on uncertainties in exposure parameters and EPCs

Uncertainty	Parameter Values/Assumptions		LOAEL HQ			
			PCDD/PCDF TEQ		Total TEQ	
	Original	Adjusted	Original	Adjusted	Original	Adjusted
Spotted Sandpiper						
Body weight	0.0425 kg	0.0471 kg	0.91	0.82	**1.2**	**1.1**
		0.0379 kg		1.0		**1.4**
SIR	18% of FIR	7.3% of FIR		0.46		0.69
		30% of FIR		**1.1**		**1.4**
FIR	64% of bw	62% of bw		0.90		**1.2**
		66% of bw		0.92		**1.3**
Treatment of non-detects	DL = 0 for non-detects	use of one-half the DL or the full DL for non-detects[a]		0.91		**1.2**
		use of Kaplan-Meier method in USEPA's TEQ calculator (USEPA 2014)		0.91		**1.1**
Great Blue Heron						
Body weight	2.3 kg	2.2 kg	0.066	0.069	0.17	0.18
		2.6 kg		0.058		0.15
SIR	1% of FIR	0% of FIR		0.058		0.16
		2% of FIR		0.073		0.18
Food ingestion rate	18% of bw	16% of bw		0.061		0.16
		20% of bw		0.074		0.19
Site use factor	1	0.5		0.033		0.085
Treatment of non-detects	DL = 0 for non-detects	use of one-half the DL or the full DL for non-detects[a]		0.066		0.17
		use of Kaplan-Meier method in USEPA's TEQ calculator (USEPA 2014)		0.066		0.13

Table 8-13. Bird dietary HQs based on uncertainties in exposure parameters and EPCs

Uncertainty	Parameter Values/Assumptions		LOAEL HQ			
			PCDD/PCDF TEQ		Total TEQ	
	Original	Adjusted	Original	Adjusted	Original	Adjusted
Belted Kingfisher						
Body weight	0.147 kg	0.136 kg	0.28	0.31	0.72	0.77
		0.158 kg		0.27		0.67
SIR	0.5% of FIR	0% of FIR		0.28		0.70
		2% of FIR		0.31		0.75
FIR	50% of bw	48% of bw		0.27		0.69
		52% of bw		0.29		0.73
Exposure area	> RM 10	site wide		0.27		0.68
Treatment of non-detects	DL = 0 for non-detects	use of one-half the DL or the full DL for non-detects[a]		0.28		0.72
		use of Kaplan-Meier method in USEPA's TEQ calculator (USEPA 2014)		0.28		0.52

[a] LOAEL HQs are the same, except where a range is presented, regardless of treatment of non-detected values as one-half the DL or as the full DL.

bw – body weight
DL – detection limit
EPC – exposure point concentration
FIR – food ingestion rate
HQ – hazard quotient
LOAEL – lowest-observed-adverse-effect level
PCDD – polychlorinated dibenzo-*p*-dioxin
PCDF – polychlorinated dibenzofuran
RM – river mile
SIR – sediment ingestion rate
TEQ – toxic equivalent
USEPA – US Environmental Protection Agency

Bold identifies HQs > 1.0.

Table 8-21. Bird egg tissue HQs based on uncertainties in exposure parameters, EPCs, and selected TRVs

Uncertainty	Parameter Values/Assumptions		LOAEL HQ			
			Total PCBs		Total TEQ	
	Original	Adjusted	Original	Adjusted	Original	Adjusted
Belted kingfisher						
Use of exposure area	> RM 6	site wide	0.62	0.61	1.0	0.95
Site use factor	1	0.5		0.31		0.50
Treatment of non-detects	DL = 0 for non-detects	DL = one-half the DL or full DL for non-detects[a]		0.62		1.0
		use of Kaplan-Meier method in USEPA's TEQ calculator (USEPA 2014)		na		0.70
Great blue heron						
Site use factor	1	0.5	0.18	0.088	**1.1**	0.53
Treatment of non-detects	DL = 0 for non-detects	DL = one-half the DL or full DL for non-detects[a]		0.18		**1.1**
		use of Kaplan-Meier method in USEPA's TEQ calculator (USEPA 2014)		na		0.78
Use of species-specific TRV	TRV based on SSD that includes species with higher sensitivity than great blue heron	TRV based on great blue heron toxicity data		ne[b]		0.46

[a] LOAEL HQs are the same, regardless of treatment of non-detected values as one-half the DL or as the full DL.

[b] A species-specific TRV was not evaluated for total PCBs and great blue heron, because species-specific toxicity data were not available.

DL – detection limit
EPC – exposure point concentration
HQ – hazard quotient
LOAEL – lowest-observed-adverse-effect level
ne – not evaluated
PCB – polychlorinated biphenyl
RM – river mile
SSD – species sensitivity distribution
TEQ – toxic equivalent
TRV – toxicity reference value
USEPA – US Environmental Protection Agency

Bold identifies HQs > 1.0.

Table 9-15. Mammal dietary HQs based on uncertainties in exposure parameters and EPCs

Uncertainty	Parameter Values/Assumptions		LOAEL HQ[a]			
			Total PCBs		Total TEQ	
	Original	Adjusted	Original	Adjusted	Original	Adjusted
River Otter						
Body weight	8.0 kg	9.2 kg	1.2	**1.0**	1.3	**1.2**
		6.7 kg		**1.4**		**1.6**
SIR	2% of FIR	1% of FIR		**1.2**		**1.4**
		4% of FIR		**1.2**		**1.6**
FIR	16% of body weight	14% of body weight		1.0		**1.2**
		18% of body weight		**1.3**		**1.4**
Exposure area	site wide	> RM 10 (SFF and sediment)[b]		**1.2**		0.92
Blue crab EPCs	WB crab samples from RM 0 to RM 10	WB data from RM 0 to RM 10 combined with estimated data for > RM 10[c]		**1.2**		**1.4**
Fish EPCs	fish EPCs calculated according to site-wide abundance	fish EPCs calculated according to data availability		**2.6**		**2.4**
Site use factor	1	0.5		0.60		0.66
Treatment of non-detects	DL = 0 for non-detects	use of one-half the DL or the full DL for non-detects[d]		**1.2**		**1.3**
		use of Kaplan-Meier method in USEPA's TEQ calculator (USEPA 2014)		na		**1.3**
Mink						
Body weight	1.0 kg	1.7 kg	0.46	0.27	0.47	0.28
		0.55 kg		0.84		0.86
SIR	2% of FIR	1% of FIR		0.45		0.44
		4% of FIR		0.47		0.54
FIR	14% of body weight	12% of body weight		0.40		0.41
		16% of body weight		0.52		0.53

Table 9-15. Mammal dietary HQs based on uncertainties in exposure parameters and EPCs

Uncertainty	Parameter Values/Assumptions		LOAEL HQ[a]			
			Total PCBs		Total TEQ	
	Original	Adjusted	Original	Adjusted	Original	Adjusted
Exposure area	> RM 10	site wide	0.46	0.46	0.47	0.64
Blue crab EPCs	WB crab samples from RM 0 to RM 10	WB data from RM 0 to RM 10 combined with estimated data for > RM 10[c]		0.44		0.41
Fish EPCs	fish EPCs calculated according to site-wide abundance	fish EPCs calculated according to data availability		**1.1**		**1.1**
SUF	1	0.5		0.23		0.24
Treatment of non-detects	DL = 0 for non-detects	use of one-half the DL or the full DL for non-detects[d]		0.46		0.47
		use of Kaplan-Meier method in USEPA's TEQ calculator (USEPA 2014)		na		0.47

[a] Both the original and revised HQs presented in this table are based on a mink diet of aquatic prey only.
[b] EPCs for crab included site-wide data because they are highly mobile and are therefore likely exposed to the entire site.
[c] UCLs calculated using WB data from RM 0 to RM10 and estimated WB data above RM 10 (see Appendix C1).
[d] LOAEL HQs are the same regardless of treatment of non-detected values as one-half the DL or as the full DL.

DL – detection limit
EPC – exposure point concentration
FIR – food ingestion rate
HQ – hazard quotient
LOAEL – lowest-observed-adverse-effect level
PCB – polychlorinated biphenyl
RM – river mile
SFF – small forage fish
SIR – sediment ingestion rate
SUF – site use factor
TEQ – toxic equivalent
UCL – upper confidence limit on the mean
USEPA – US Environmental Protection Agency
WB – whole body

Bold identifies HQs > 1.0.

4 Data Evaluation and Reduction

This section provides a summary of the criteria used for establishing acceptable chemistry and toxicity datasets for use in the BERA (i.e., data quality objectives [DQOs]); a description of the sediment, tissue, and water data considered acceptable for use in the BERA; and the methods for reducing chemistry data for risk calculations. This section also describes survey data collected for use in the BERA. Additional details on the data evaluation criteria and data reduction methods are presented in the *Revised Data Usability and Data Evaluation Plan for the Lower Passaic River Study Area Risk Assessments* (Windward and AECOM [in prep]-a), hereafter referred to as the Revised Data Usability Plan.

4.1 DATA QUALITY OBJECTIVES

Data used to define potential exposure and / or estimate potential risks (i.e., exposure point concentrations [EPCs] based on chemistry data or metrics based on toxicity or community data) underwent an evaluation to determine if the data quality was appropriate for the intended data use and therefore met the DQOs. The DQO review process was consistent with USEPA risk guidance (USEPA 1992). Five general levels for defining / applying DQOs were identified: event, location, sample, result, and validation. These DQOs are outlined in Table 4-1 and detailed in the Revised Data Usability Plan (Windward and AECOM [in prep]-a). Only those data that met the specified DQOs were used in this BERA.

Table 4-1. DQOs for the BERA dataset

Event Level
DQO No. 1 – Original hard copies or electronic copies of data report(s) must be available.
DQO No. 2 – Data must represent current conditions.
Location Level
DQO No. 1 – Sediment cannot be collected from dredged[a] or capped areas.
DQO No. 2 – Field coordinates must be available to verify where data were collected.
Sample Level
DQO No. 1 – Sample depth interval must be identified.
DQO No. 2 – Sample and/or analysis type must be clearly identified.
Result Level
DQO No. 1 – DLs must be appropriately reported.
DQO No. 2 – Constituent parameters for summations must be available.
DQO No. 3 – Chemical analytical methods must be acceptable.
DQO No. 4 – Toxicity and bioaccumulation test methods must be acceptable.
DQO No. 5 – Invertebrate community data must be reported to the lowest practical taxonomic level.
DQO No. 6 – Benthic invertebrate community metric calculations must be documented.

Table 4-1. DQOs for the BERA dataset

Validation Level
DQO No. 1 – Chemistry data must be validated and include validation qualifiers, or sufficient information must be available to validate data.
DQO No. 2 – Sufficient information must be available to confirm the quality of the biological test data.
DQO No. 3 – Sufficient information must be available to confirm the quality and comparability of the taxonomic data.
DQO No. 4 – Chemistry data reports must contain laboratory-generated forms that include results for each sample.
DQO No. 5 – Existence and location of documentation that supports the dataset must be known.

[a] Includes dredged areas that have been backfilled with clean material.

BERA – baseline ecological risk assessment

DL – detection limit

DQO – data quality objective

All chemistry and toxicity data collected during sampling events implemented by CPG since the beginning of the CPG-led LPRSA RI (initiated in 2007) were considered for use in this BERA for the calculation of risk estimates. CPG-led QAPPs specified DQOs that were consistent with USEPA guidance to ensure that the data collected were of sufficient quality to support the RI, including the risk assessments. During the December 14 and 16, 2010, meetings between USEPA and CPG representatives, it was agreed that the EPCs in the risk assessments would be calculated using only current (i.e., CPG) data that met the DQOs specified in Table 4-1.[29] All data collected by CPG with the intention of being used in the risk assessments (detailed in Section 4.2) were considered appropriate for the calculation of risk estimates and met the DQOs outlined in Table 4-1 with the exception of the following:

- Surface sediment data collected from all areas that have since been dredged (i.e., RM 10.9 and Lister Avenue dredge areas)[30]
- Subsurface sediment data (sediment below the sediment depth associated with ecological exposure)[31]

4.2 DATA USED IN THE BERA

This section describes the surface sediment chemistry data, surface sediment toxicity data, tissue chemistry data, water chemistry data, and data from various biological surveys used in the BERA. Per the agreement between USEPA and CPG, only data

[29] Older data (collected prior to the initiation of the CPG-led LPRSA RI) may be considered when evaluating nature and extent and time-related trends.

[30] These areas were excluded because sediment has been dredged; therefore, samples do not represent current conditions, as required by station-level DQO No. 1 (Table 4-1).

[31] These data were excluded because only sediment data collected from the depth interval of 0 to 15 cm (0 to 6 in.) below the sediment surface were considered acceptable for inclusion in both risk assessments, as required by sample-level DQO No. 1 (Windward and AECOM [in prep]-a).

collected by CPG since 2007 were considered to be representative of current conditions within the LPRSA and used in deriving exposure concentrations in the risk assessments. Data used to define background conditions were based on both data collected by CPG (above Dundee Dam since 2007) per the USEPA-approved benthic QAPP (Windward 2012a) and regional data collected by other parties (some regional data collected prior to 2007) from areas as directed by USEPA (USEPA 2013a). Appendix K provides the LPRSA BERA dataset, and Appendix L provides the background and reference dataset.

4.2.1 Sediment chemistry data

Only sediment data collected from the depth interval of 0 to 15 cm (0 to 6 in.) below the sediment surface were included for the derivation of risk estimates and in the evaluation of background. As discussed in Section 2.2.1, the LPRSA benthic invertebrate community is dominated by fairly shallow-dwelling deposit feeders and detritivores (e.g., annelid worms, chironomids, and bivalves), the burrowing depth of which is generally limited by a shallow RPD layer approximately 2 cm thick. The chemical signatures in sediment from this shallow biologically active zone (the 0-to-2-cm depth interval) may differ from the chemical signatures of deeper sediments collected from the LPRSA (from 0 to 15 cm).

Surface sediment chemistry data used in the BERA were for samples collected during six sampling events from 2008 to 2012 as follows (Table 4-2, Figure 4-1):

- 2008 low-resolution coring (LRC) sampling[32]
- 2009 surface sediment sampling[33]
- 2010 surface sediment sampling (co-located with tissue samples)
- 2011 RM 10.9 sediment characterization sampling[34]
- 2012 RM 10.9 sediment characterization sampling[35]
- 2012 LRC supplemental sampling program (SSP)

LPRSA sediment chemistry data collected after 2012 (i.e., SSP2) were excluded from the BERA dataset because validated data were not available prior to completing the LPRSA SLERA (Appendix A). The BERA sediment chemistry dataset (six sampling events) used for the BERA was compared with a dataset that included the 2013 LRC SSP2 event (seven sampling events) in Appendix K. Mean concentrations of the sediment COPECs were generally similar between the two datasets with an average

[32] One location from RM 10.9 dredge area was excluded.
[33] Two locations from RM 10.9 dredge area and one location from the Lister Avenue dredge area were excluded.
[34] Twenty-two locations from RM 10.9 dredge area were excluded.
[35] Five locations from RM 10.9 dredge area were excluded.

relative percent difference of 5% (Appendix K). Based on this comparison, the use of the data from the six sediment sampling events as the basis for the BERA sediment evaluation is not expected to underestimate current risks.

Background datasets were developed for both freshwater and estuarine sediment chemistry:

- Freshwater background concentrations (i.e., urban habitat) were derived from sediment samples collected by CPG from above Dundee Dam in 2008 and 2012 (Figure 4-2).
- Two datasets were developed for estuarine background using regional data collected by non-CPG parties. Sediment samples collected from Jamaica Bay (New York) from 1993 to 2005 were used to derive background estuarine sediment concentrations (Figure 4-3) representative of a similarly urban environment. Sediment samples collected from the Mullica River and Great Bay from 1999 to 2006 were used to derive estuarine background sediment concentrations (rural habitat) (Figure 4-4). Only sediment chemistry data with co-located toxicity data were used. The regional background datasets were identified by USEPA for use in the BERA as background and reference datasets as discussed in Appendix B to the Revised RARC Plan (Windward and AECOM [in prep]-b).

4.2.2 Sediment toxicity data

LPRSA sediment toxicity test data used in the BERA were from 98 of the 107 surface (0 to 15 cm) sediment locations sampled in 2009 for sediment chemistry (Table 4-2, Figure 4-5).[36] These 98 LPRSA sediment chemistry and toxicity samples were also analyzed for benthic invertebrate community indices to support the sediment quality triad (SQT) evaluation. As discussed in Section 2.2.1, the LPRSA benthic invertebrate community is dominated by fairly shallow-dwelling deposit feeders and detritivores (e.g., annelid worms, chironomids, and bivalves), the burrowing depth of which are generally limited by a shallow RPD layer approximately 2 cm thick. The chemical signatures in sediment from this shallow biologically active zone (the 0-to-2-cm depth interval) may differ from the chemical signatures of deeper sediments collected from the LPRSA (from 0 to 15 cm).

The following toxicity tests were conducted using LPRSA sediment:

- 10-day amphipod (*Ampelisca abdita*) survival (27 estuarine locations)

[36] Two SQT sampling locations were in the RM 10.9 dredge area, and one SQT sampling location was in the Lister Avenue dredge area. These three SQT sampling locations are not in the chemistry dataset but have been retained for SQT analysis to understand relationships between synoptic data collected in 2009 (before dredging).

- 10-day midge (*Chironomus dilutus*) survival and growth (71 freshwater locations)
- 28-day amphipod (*Hyalella azteca*) survival and growth test (98 locations; 27 estuarine and 71 freshwater locations)

For the evaluation of reference information, toxicity test data included 24 surface (0 to 15 cm) sediment samples with co-located sediment chemistry and benthic invertebrate community data (i.e., SQT locations) from above Dundee Dam in 2012 (Figure 4-6). Reference information also included toxicity test data for surface (0 to 15 cm) sediment samples with co-located chemistry samples collected from Jamaica Bay from 1999 to 2005 and Mullica River and Great Bay from 1999 to 2006 (Figures 4-3 and 4-4, respectively). Toxicity test reference information was available for the following:

- 10-day amphipod (*A. abdita*) survival (66 Jamaica Bay locations and 20 Mullica River and Great Bay locations)
- 10-day midge (*C. dilutus*) survival and growth (24 locations above Dundee Dam)
- 28-day amphipod (*H. azteca*) survival and growth (24 locations above Dundee Dam)

Table 4-2. Sediment chemistry and toxicity data included in the BERA dataset

Sampling Event	Sampling Period	Description	Number of Locations	Chemical Group/Toxicity Test	Source
LPRSA					
2008 LRC program	July to December 2008	low-resolution coring/sediment sampling throughout 17.4-mi LPRSA and tributaries; only surface (i.e., 0 to 15 cm) sediment data were used	98	metals, SEM metals, butyltins, PAHs, alkylated PAHs, SVOCs, PCB Aroclors, PCB congeners, PCDDs/PCDFs, organochlorine pesticides, herbicides, VOCs, TPH, general chemistry (i.e., AVS, ammonia, cyanide, Kjeldahl nitrogen, phosphorus, and total sulfide), TOC, and grain size	AECOM (2014)
2009 benthic sediment sampling	October to November 2009	surface (0 to 15 cm) sediment grab samples collected throughout 17.4-mi LPRSA	107	metals, SEM metals, butyltins, PAHs, alkylated PAHs, SVOCs, PCB Aroclors, PCB congeners, PCDDs/PCDFs, organochlorine pesticides, herbicides, VOCs, TPH, general chemistry (i.e., AVS, ammonia, cyanide, Kjeldahl nitrogen, phosphorus, and total sulfide), TOC, and grain size	Windward ([in prep]-a)
			98[a, b]	whole sediment toxicity tests using the following test methods: 10-day *A. abdita* survival (estuarine sediment), 10-day *C.dilutus* survival and growth (freshwater sediment), 28-day *H. azteca* survival and growth (estuarine and freshwater sediment)	Windward ([in prep]-l)
2010 benthic sediment sampling	August 2010	surface (0 to 15 cm) sediment grab samples collected at locations where SFF were collected	21	metals, SEM metals, butyltins, PAHs, alkylated PAHs, SVOCs, PCB Aroclors, PCB congeners, PCDDs/PCDFs, organochlorine pesticides, herbicides, VOCs, TPH, general chemistry (i.e., AVS, ammonia, cyanide, Kjeldahl nitrogen, phosphorus, and total sulfide), TOC, and grain size	Windward ([in prep]-a)
2011 RM 10.9 sediment investigation	August to November 2011	coring/sediment sampling in the vicinity of RM 10.9, only surface (i.e., 0 to 15 cm) sediment data were used	32	metals, SEM metals, butyltins, PAHs, alkylated PAHs, SVOCs, PCB Aroclors, PCB congeners, PCDDs/PCDFs, organochlorine pesticides, herbicides, VOCs, TPH, general chemistry (i.e., AVS, ammonia, cyanide, Kjeldahl nitrogen, phosphorus, and total sulfide), TOC, and grain size	ddms (2013b)
2012 LRC supplemental investigation	January to February 2012	low-resolution coring/sediment sampling throughout 17.4-mi LPRSA; only surface (i.e., 0 to 15 cm) sediment data were used	85	metals, SEM metals, butyltins, PAHs, alkylated PAHs, SVOCs, PCBs Aroclors, PCB congeners, PCDDs/PCDFs, organochlorine pesticides, VOCs, TPH, general chemistry (i.e., AVS, ammonia, cyanide, Kjeldahl nitrogen, phosphorus, and total sulfide), TOC, and grain size	ddms (2013g)
2012 RM 10.9 sediment investigation (Addendum A)	May 2012	sediment cores collected in the vicinity of RM 10.9; only surface (i.e., 0 to 15 cm) sediment data were used	10	metals, butyltins, PAHs, alkylated PAHs, SVOCs, PCB Aroclors, PCB congeners, PCDDs/PCDFs, organochlorine pesticides, VOCs, TPH, general chemistry (i.e., cyanide), TOC, and grain size	ddms (2013h)

Table 4-2. Sediment chemistry and toxicity data included in the BERA dataset

Sampling Event	Sampling Period	Description	Number of Locations	Chemical Group/Toxicity Test	Source
Passaic River Above Dundee Dam					
2008 LRC program	September to October 2008	low-resolution coring/sediment sampling above Dundee Dam	6	metals, SEM metals, butyltins, PAHs, alkylated PAHs, SVOCs, PCBs Aroclors, PCB congeners, PCDDs/PCDFs, organochlorine pesticides, herbicides, VOCs, TPH, general chemistry (i.e., AVS, ammonia, cyanide, Kjeldahl nitrogen, phosphorus, and total sulfide), TOC, and grain size DFs, SVOCs, TPH, VOCs, and wet chemistry	AECOM (2014)
2012 upstream sediment sampling	November 2012	surface (0 to 15 cm) sediment grab samples collected above Dundee Dam	40	metals, SEM metals, butyltins, PAHs, alkylated PAHs, SVOCs, PCBs Aroclors, PCB congeners, PCDDs/PCDFs, organochlorine pesticides, VOCs, TPH, general chemistry (i.e., AVS, ammonia, cyanide, Kjeldahl nitrogen, total phosphorus, and sulfide), TOC, and grain size	Windward ([in prep]-h)
			24	toxicity tests using the following test methods: 10-day *C dilutus* survival and growth, 28-day *H. azteca* survival and growth	Windward ([in prep]-i)
Jamaica Bay					
1999 CARP sediment ambient study	August 1999	surface sediment grab samples (0 to 15 cm) collected from Jamaica Bay	1	metals, PAHs, alkylated PAHs, SVOCs, PCB congeners, PCDDs/PCDFs, organochlorine pesticides, TOC, grain size	NOAA (2013)
				toxicity test based on 10-day *A. abdita* survival	
2000 to 2005 NCA Program New York/New Jersey Harbor	August 2000 to August 2005	surface sediment grab samples (0 to 15 cm) collected from Jamaica Bay	9	metals, PAHs, SVOCs, PCB congeners, organochlorine pesticides, TOC, and grain size	
				sediment toxicity test based on 10-day *A. abdita* survival	
1993 to 1998 REMAP	September 1993 to August 1998	surface sediment grab samples (0 to 15 cm) collected from Jamaica Bay	56	metals, SEM metals, PAHs, SVOCs, PCDDs/PCDFs, organochlorine pesticides, general chemistry (e.g., AVS, ammonia, cyanide, Kjeldahl nitrogen, total sulfide), TOC, grain size	
				sediment toxicity test based on 10-day *A. abdita* survival	

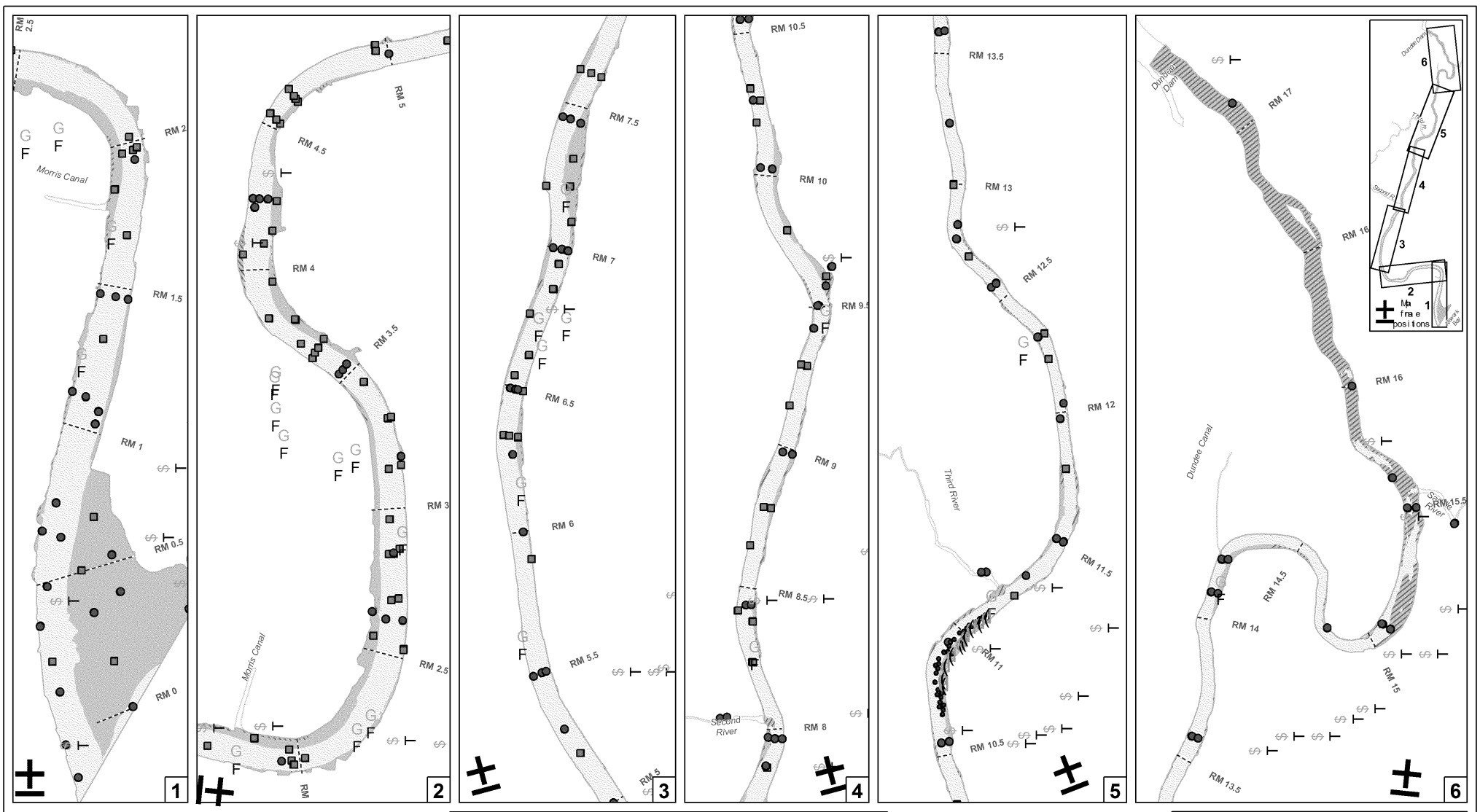
Table 4-2. Sediment chemistry and toxicity data included in the BERA dataset

Sampling Event	Sampling Period	Description	Number of Locations	Chemical Group/Toxicity Test	Source
Mullica River and Great Bay					
1999 late summer/early fall RI-ESP sampling program	October 1999	surface sediment grab samples (0 to 15 cm) collected from Mullica River and Great Bay	3	metals, PAHs, PCB Aroclors, PCDDs/PCDFs, and organochlorine pesticides	NOAA (2013)
				toxicity test based on 10-day *A. abdita* survival	
1990 to 1993 EMAP-Delaware Bay	August 1990 to August 1993	surface sediment grab samples (0 to 15 cm) collected from Mullica River and Great Bay	5	metals, PAHs, SVOCs, PCB congeners, and organochlorine pesticides	NOAA (2013)
				toxicity test based on 10-day *A. abdita* survival	
2003 to 2006 NCA Program New Jersey Atlantic Coast	October 2003 to August 2006	surface sediment grab samples (0 to 15 cm) collected from Mullica River and Great Bay	12	metals, PAHs, SVOCs PCB congeners, organochlorine pesticides, TOC, and grain size	NOAA (2013)
				toxicity test based on 10-day *A. abdita* survival	

[a] Two SQT sampling locations were in the RM 10.9 dredge area, and one SQT sampling location was in the Lister Avenue dredge area. These three SQT sampling locations are not in the chemistry dataset but have been retained for SQT analysis to understand relationships between synoptic data collected in 2009 (before dredging).

[b] The sediment from one location was collected for chemistry analysis and toxicity testing only; samples from 97 locations with chemistry and toxicity test data were co-located with benthic invertebrate community survey samples.

AVS – acid volatile sulfide
CARP – Contaminant Assessment and Reduction Project
EMAP – Environmental Monitoring and Assessment Program
ESP – ecological sampling program
LPRSA – Lower Passaic River Study Area
LRC – low-resolution coring
NCA – National Coastal Assessment
NOAA – National Oceanic and Atmospheric Administration
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
PCDD – polychlorinated dibenzo-*p*-dioxin
PCDF – polychlorinated dibenzofuran
REMAP – Regional Environmental Monitoring and Assessment Program
RI – remedial investigation
RM – river mile
SEM – simultaneously extracted metals
SFF – small forage fish
SQT – sediment quality triad
SVOC – semivolatile organic compound
TOC – total organic carbon
TPH – total petroleum hydrocarbons
VOC – volatile organic compound



WindWard environmental LLC

0 2.5 5 10 Kilometers

0 2.5 5 Miles

Event
- Sediment investigation (Round A)
- Supplemental investigation
- Sediment investigation
- Benthic Sediment Sampling
- Benthic Sediment Sampling
- Biota

- River mile
- Mudflats
- Groundwater fines
- LPRSA

Mudflats are geologic features observed where river bottom slopes decrease and silts settle. Determined from bathymetric survey.

Figure 4-1. LPRSA locations for surface sediment chemistry samples

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Prepared/Updated by: ... Date: ... Path: ...\Figure 4-1 Surface Sediment Locations.mxd

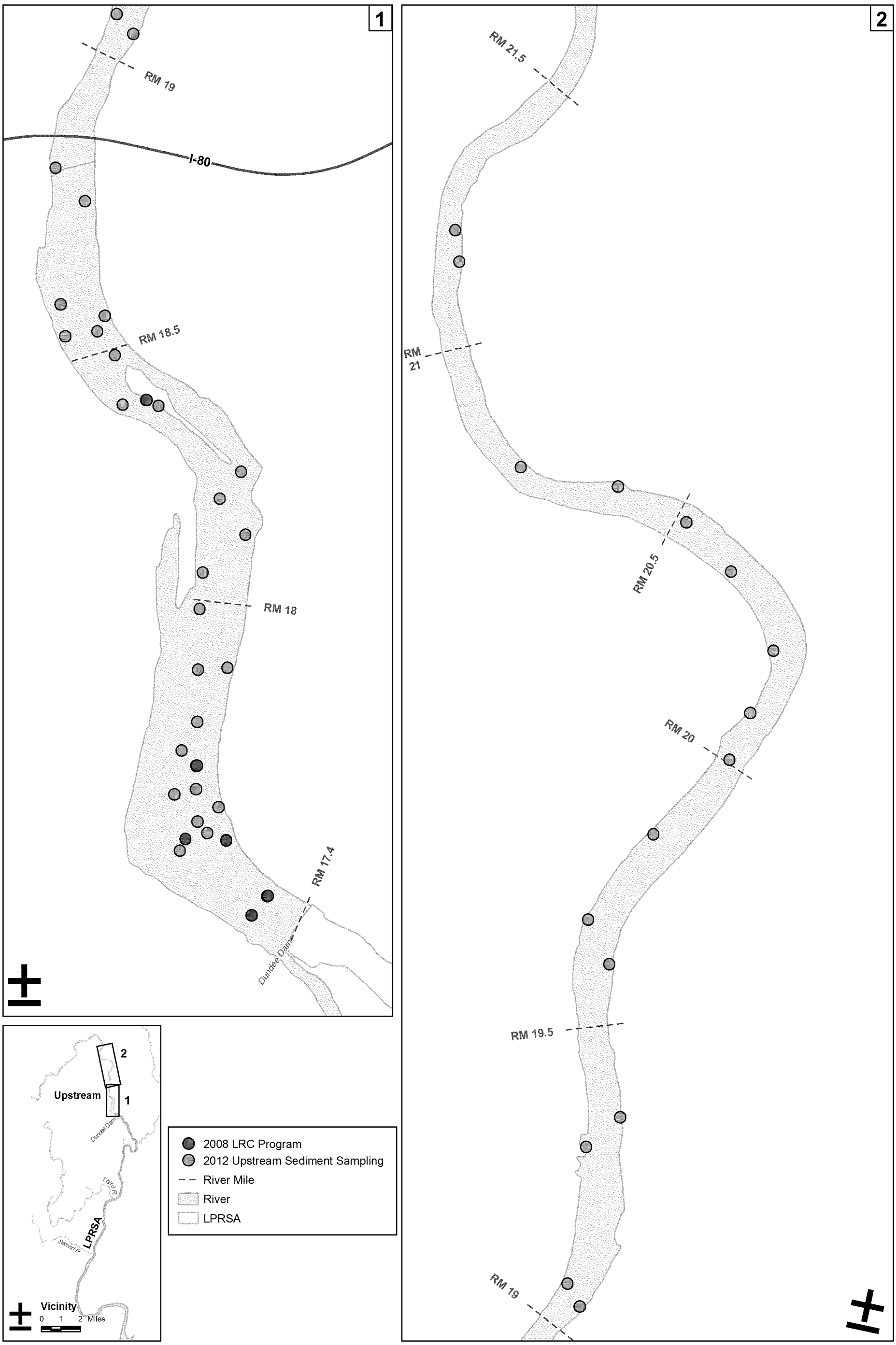

Figure 4-2. Locations above Dundee Dam for surface sediment chemistry samples

DRAFT

Data sources: river miles were derived from USGS NHD Streams.

Prepared by lindam 6/4/2014; W:\Projects\06-58-01 Passaic RI\Data\GIS\Maps_and_Analysis\BERA\5726_Locations above Dundee Dam for surface sediment chemistry samples_MTY_20131112.mxd

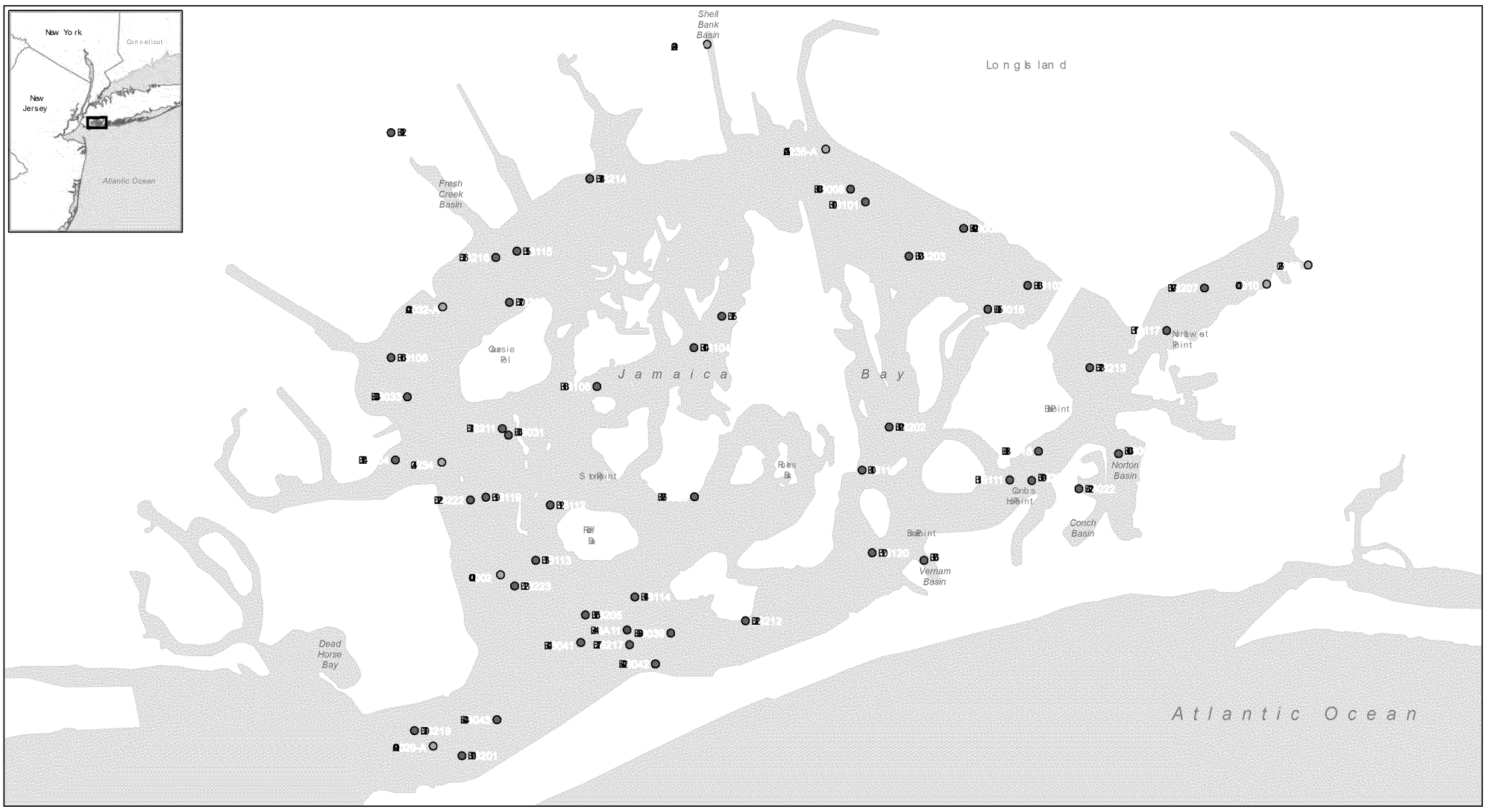

Figure 4-3. Jamaica Bay locations for surface sediment chemistry samples and toxicity data

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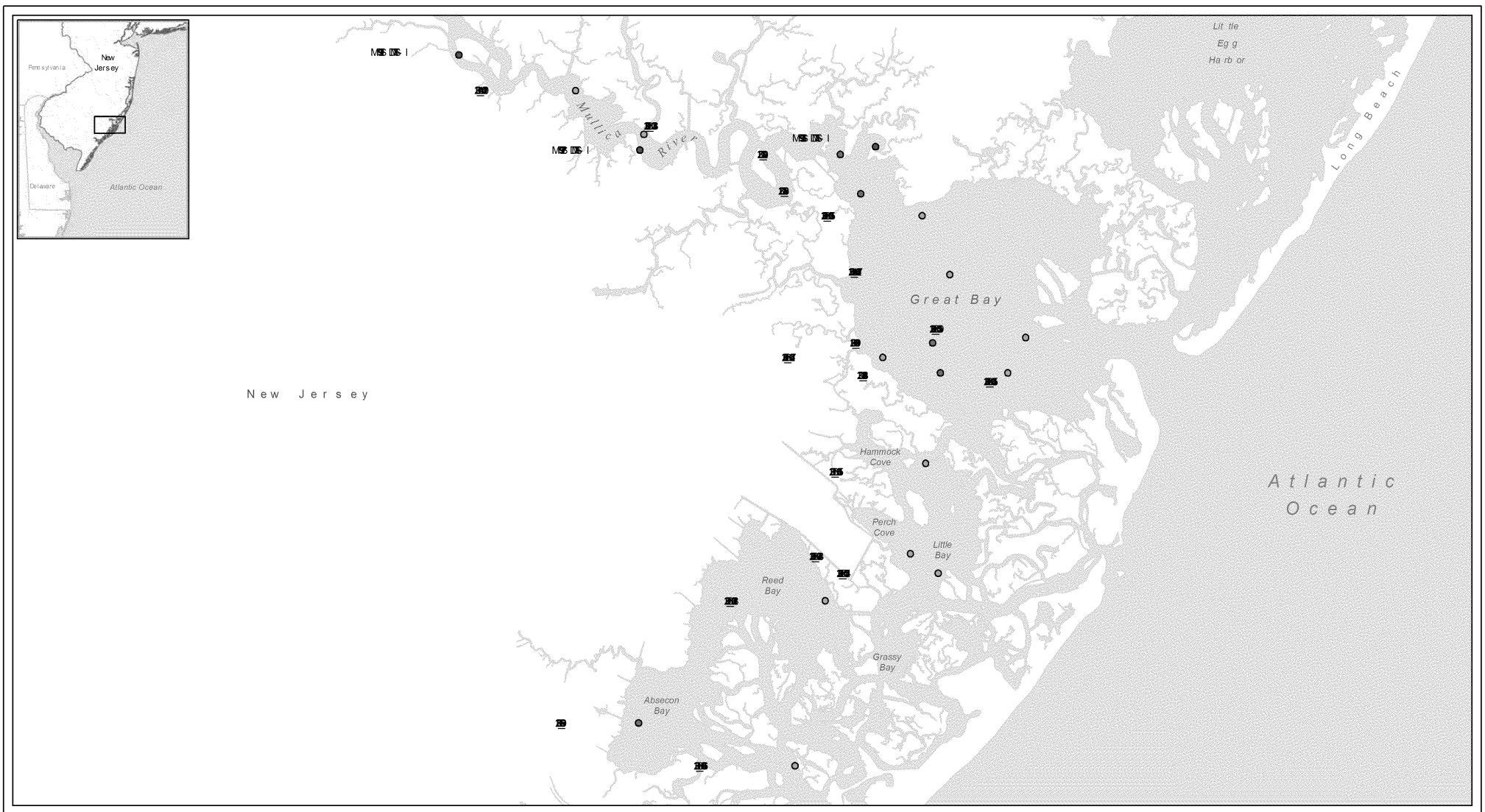

Figure 4-4. Mullica River and Great Bay locations for surface sediment chemistry samples and toxicity data

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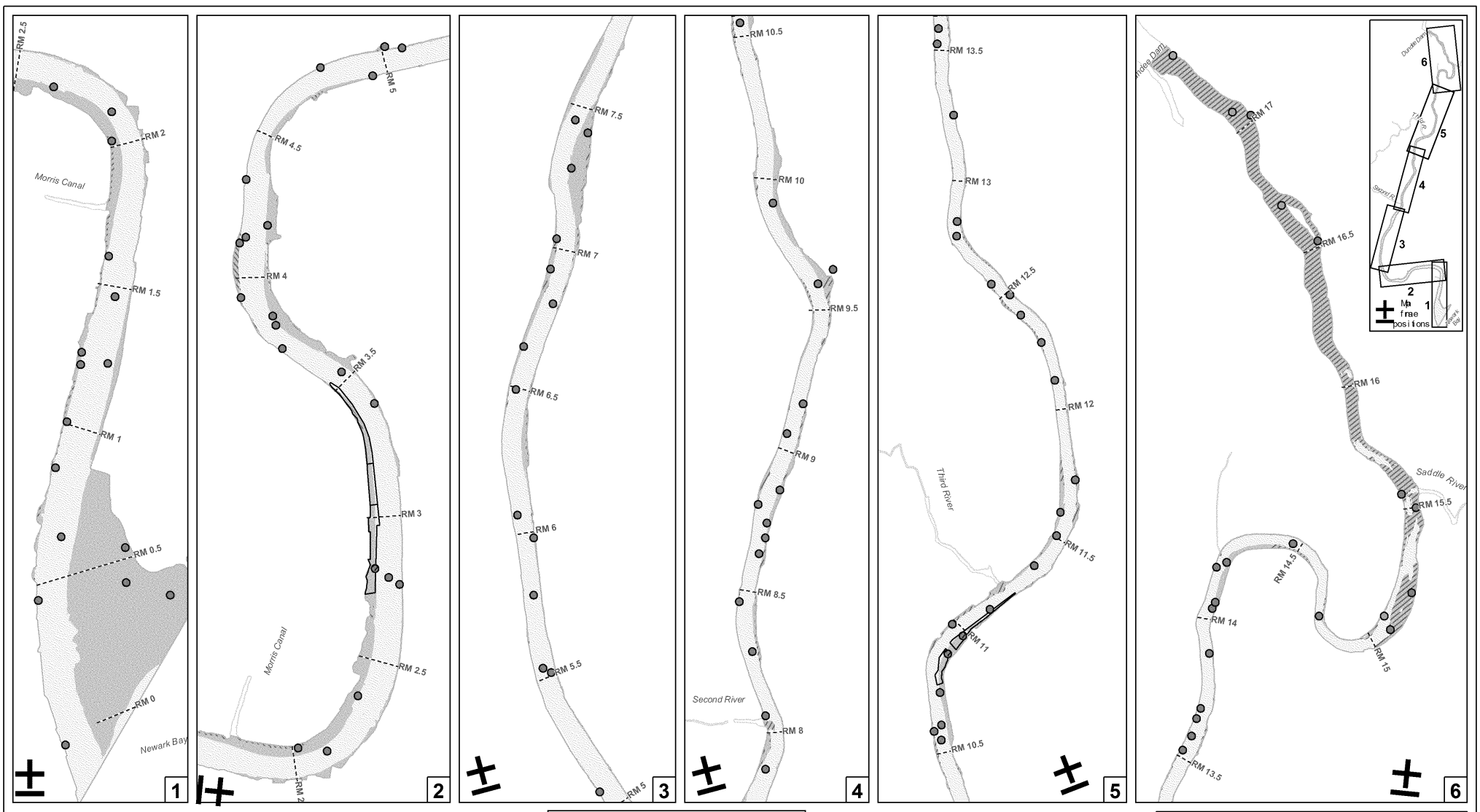

Figure 4-5. LPRSA locations for SQT samples

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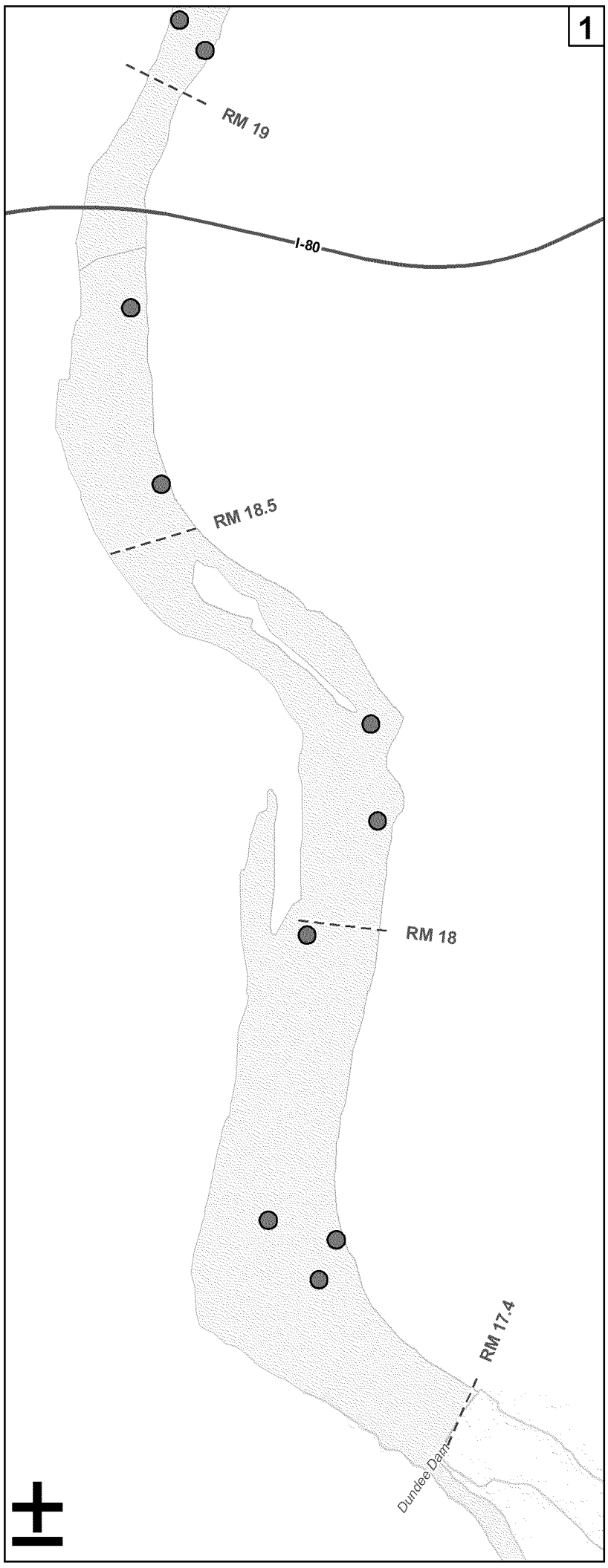

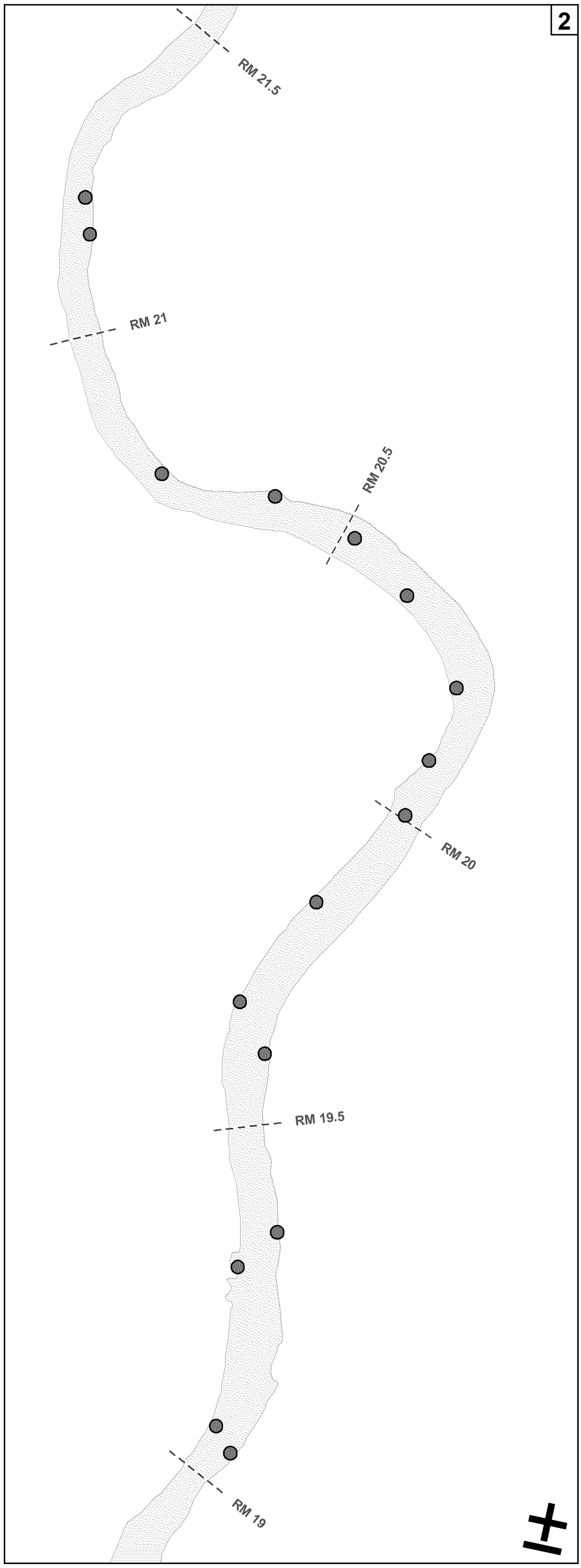

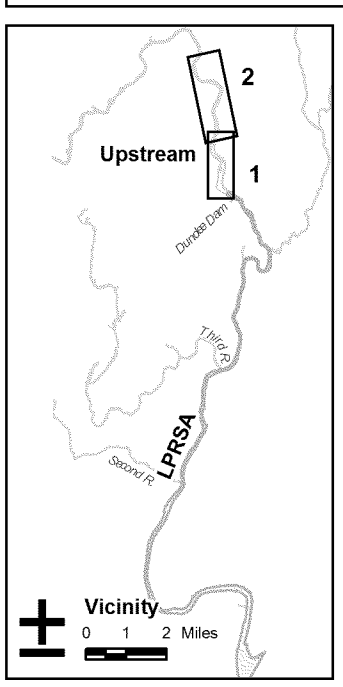

SQT location
River Mile
River
LPRSA

0 500 1,000 Feet

Figure 4-6. Locations above Dundee Dam for SQT samples

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Data sources: river miles were derived from USGS NHD Streams.
Imagery from ESRI; http://goto.arcgisonline.com/maps/World_Imagery

Prepared by LSM 6/4/2014; W:\Projects\06-58-01 Passaic RI\Data\GIS\Maps_and_Analysis\BERA\5417_Upstream actual SQT sed locs_CEH_20131204.mxd

4.2.3 Tissue chemistry data

Fish and crab tissue chemistry data used in the BERA were for samples collected from the LPRSA in 2009 and 2010 for the following species: American eel, blue crab, brown bullhead, carp, channel catfish, largemouth bass, northern pike, smallmouth bass, white catfish, white perch, white sucker, and SFF (i.e., gizzard shad, mixed forage fish, mummichog, pumpkinseed, silver shiner, spottail shiner, and white perch)[37] (Table 4-3; Figures 4-7 through 4-15). The LPRSA tissue chemistry dataset also included estuarine worm (*Nereis virens)* and freshwater worm (*Lumbriculus variegatus*) data from 28-day laboratory bioaccumulation studies conducted using sediment collected from throughout the LPRSA in 2010 (Figure 4-16) and Eastern elliptio mussel and ribbed mussel data from an *in situ* caged bivalve study conducted in 2011 (Figure 4-17).[38] Only whole-body concentrations were used to develop exposure concentrations in the BERA. Whole-body concentrations were estimated from individual fillet and carcass concentrations for some fish samples and from muscle / hepatopancreas for some blue crab samples (see Section 4.3.4).

Background datasets were developed using tissue samples collected by CPG from above Dundee Dam in 2012 and tissue samples collected by non-CPG parties from Jamaica Bay and Lower Harbor from 1978 to 2000 and from Mullica River and Great Bay in 1999 and 2000 (Table 4-3).[39] Species collected from above Dundee Dam included American eel, brown bullhead, carp, channel catfish, northern pike, smallmouth bass, white perch, white sucker, and SFF (i.e., pumpkinseed, silver shiner, and banded killifish) at sampling locations shown in Figures 4-18 through 4-24. Species collected from Jamaica Bay and Lower Harbor included banded killifish, mummichog, and other killifish species at sampling locations shown in Figure 4-25. Mummichog was the only type of fish collected from the Mullica River and Great Bay; sampling locations are shown in Figure 4-26.

[37] Mixed-species composites were composed of multiple small forage fish species, including Atlantic shiner, bluegill, gizzard shad, inland silverside, spottail shiner, smallmouth bass, striped bass, striped mullet, tessellated darted, and white perch (Windward [in prep]-d).

[38] Mussel tissue data were normalized to Day 0 of the caged bivalve study.

[39] Background datasets included only species and tissue types that were used in the BERA dataset.

Table 4-3. Tissue data included in the BERA dataset

Sampling Event	Sampling Period	Species	Tissue Type	Number of Samples	Chemical Group	Source
LPRSA						
2009 fish and decapod tissue collection	August to September 2009	American eel	whole-body composites and individuals	19	metals, butyltins, PAHs, alkylated PAHs, SVOCs, PCB Aroclors, PCB congeners, PCDDs/PCDFs, organochlorine pesticides, lipids, and percent moisture	Windward ([in prep]-c)
			whole-body (calculated) composite and individual[a]	2		
		blue crab	whole-body (calculated) composites[b]	24		
			muscle-only composites	21		
			hepatopancreas-only composites	7		
		brown bullhead	whole-body individuals	6		
		carp[c]	whole-body individuals	12		
		channel catfish	whole-body individuals (calculated)	11		
		largemouth bass	whole-body (calculated) composites and individuals[a]	3		
		northern pike	whole-body (calculated) individual[a]	1		
		smallmouth bass	whole-body (calculated) composites[a]	3		
		white catfish	whole-body (calculated) individuals[a]	19		
		white perch	whole-body composites and individuals	19		
			whole-body (calculated) individual[a]	1		
		white sucker[c]	whole-body (calculated) individuals[a]	5		

Table 4-3. Tissue data included in the BERA dataset

Sampling Event	Sampling Period	Species	Tissue Type	Number of Samples	Chemical Group	Source
2009 laboratory bioaccumulation evaluation	December 2009 to January 2010	estuarine worm (*Nereis virens)*	whole-body composites	5	metals, butyltins, PAHs, SVOCs, PCB congeners, PCDDs/PCDFs, organochlorine pesticides, lipids, and percent moisture[e]	Windward ([in prep]-a)
		freshwater worm (*Lumbriculus variegatus*)		14[d]		
2010 spring SFF reconnaissance sampling	May 2010	mummichog	egg composites	10	lipids	Windward ([in prep]-c)
2010 SFF tissue collection	June to August 2010	mummichog	whole-body composites	18	metals, butyltins, PAHs, alkylated PAHs, organochlorine pesticides, PCB Aroclors, PCB congeners, PCDDs/PCDFs, SVOCs, lipids, and percent moisture	Windward ([in prep]-d)
		gizzard shad		3		
		pumpkinseed		1		
		silver shiner		1		
		spottail shiner		1		
		mixed forage fish[f]		4		
		white perch		2		
2011 caged bivalve study	March to June 2011	Eastern elliptio mussel (freshwater)	soft-tissue composites[g]	5[g]	metals, butyltins, PAHs, alkylated PAHs, SVOCs, PCB Aroclors, PCB congeners, PCDDs/PCDFs, organochlorine pesticides, lipids, and percent moisture	Windward ([in prep]-e)
		ribbed mussel (estuarine)		3[g]		

Table 4-3. Tissue data included in the BERA dataset

Sampling Event	Sampling Period	Species	Tissue Type	Number of Samples	Chemical Group	Source
Passaic River above Dundee Dam						
2012 upstream tissue sampling	October 2012	American eel	whole-body individuals	6	metals, butyltins, SVOCs, PAHs, alkylated PAHs, PCB Aroclors, PCB congeners, PCDDs/PCDFs, organochlorine pesticides, lipids, and percent moisture	Windward ([in prep]-g)
			whole-body (calculated) composites and individuals[a]	10		
		banded killifish	whole-body composite	1		
		brown bullhead	whole-body individuals	6		
		carp[c]	whole-body individuals	5		
			whole-body (calculated) individuals[a]	5		
		channel catfish	whole-body (calculated) individuals[a]	4		
		Northern pike	whole-body (calculated)[a] individual	1		
		pumpkinseed	whole-body composite	1		
		silver shiner	whole-body composite	1		
		smallmouth bass	whole-body (calculated) composites[a]	3		
		white perch	whole-body (calculated) composites	8		
		white sucker[c]	whole-body (calculated) individuals[a]	5		
Jamaica Bay/Lower Harbor						
1978 NYSDEC	July 1978	banded killifish	whole-body composites	2	metals	NOAA (2013)
		killifish species	whole-body composites	2	metals	
Fall1999 harbor fish collection	November 1999	mummichog	whole-body composites	2	metals, PAHs, PCB Aroclors, PCB congeners, PCDDs/PCDFs, and organochlorine pesticides	Litten (2003)

Table 4-3. Tissue data included in the BERA dataset

Sampling Event	Sampling Period	Species	Tissue Type	Number of Samples	Chemical Group	Source
Summer 1999 harbor fish collection	September 1999	mummichog	whole-body composites	5	metals, PAHs, PCB Aroclors, PCB congeners, PCDDs/PCDFs, and organochlorine pesticides	Litten (2003)
Mullica River/Great Bay						
1999 late summer/early fall RI-ESP sampling program	October 1999	mummichog	whole-body composites	9	metals, PAHs, PCB Aroclors, PCB congeners, PCDDs/PCDFs, organochlorine pesticides, and lipids	NOAA (2013)
2000 spring RI-ESP sampling program	May 2000			3		

[a] Fish whole-body tissue concentrations were calculated using fillet and carcass tissue concentrations as described in Section 4.2.4.

[b] Crab whole-body tissue concentrations were calculated using muscle/hepatopancreas and carcass concentrations as described in Section 4.2.4. Seventeen muscle/hepatopancreas crab samples collected above RM 10 did not have corresponding carcass samples to calculate whole-body concentrations. These samples were evaluated in the uncertainty section.

[c] Data were only included in the uncertainty section.

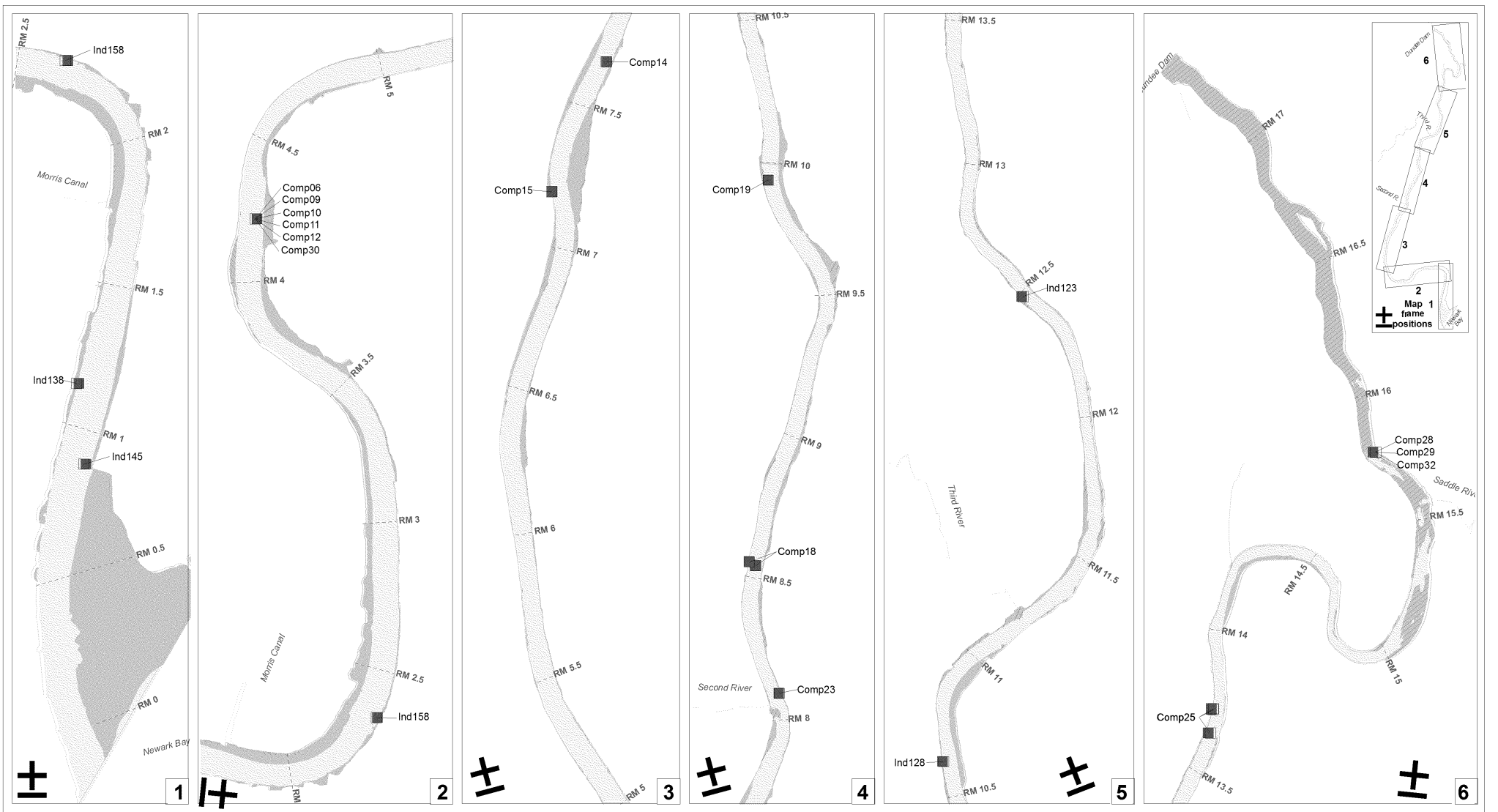
[d] The sediment used in the laboratory bioaccumulation study for one sample (LPRT11E) was collected in the RM 10.9 dredge area.

[e] The five *N. virens* tissue samples had sufficient mass for analysis of the full set of analytes; the reduced analyte priority list presented in the benthic tissue analysis plan (Windward 2010h) was followed for *L. variegatus* tissue samples because of mass limitations for some samples.

[f] Mixed-species composites were composed of multiple SFF species, including Atlantic shiner, bluegill, gizzard shad, inland silverside, spottail shiner, smallmouth bass, striped bass, striped mullet, tessellated darted, and white perch (Windward [in prep]-d).

[g] Mussel tissue data were normalized to Day 0 of the caged bivalve study.

CARP – Contamination Assessment and Reduction Program
ESP – ecological sampling program
LPRSA – Lower Passaic River Study Area
NOAA – National Oceanic and Atmospheric Administration
NYSDEC – New York State Department of Environmental Conservation
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
PCDD – polychlorinated dibenzo-*p*-dioxin
PCDF – polychlorinated dibenzofuran
RI – remedial investigation
RM – river mile
SFF – small forage fish
SVOC – semivolatile organic compound



0 0.5 Kilometers

0 0.25 Miles

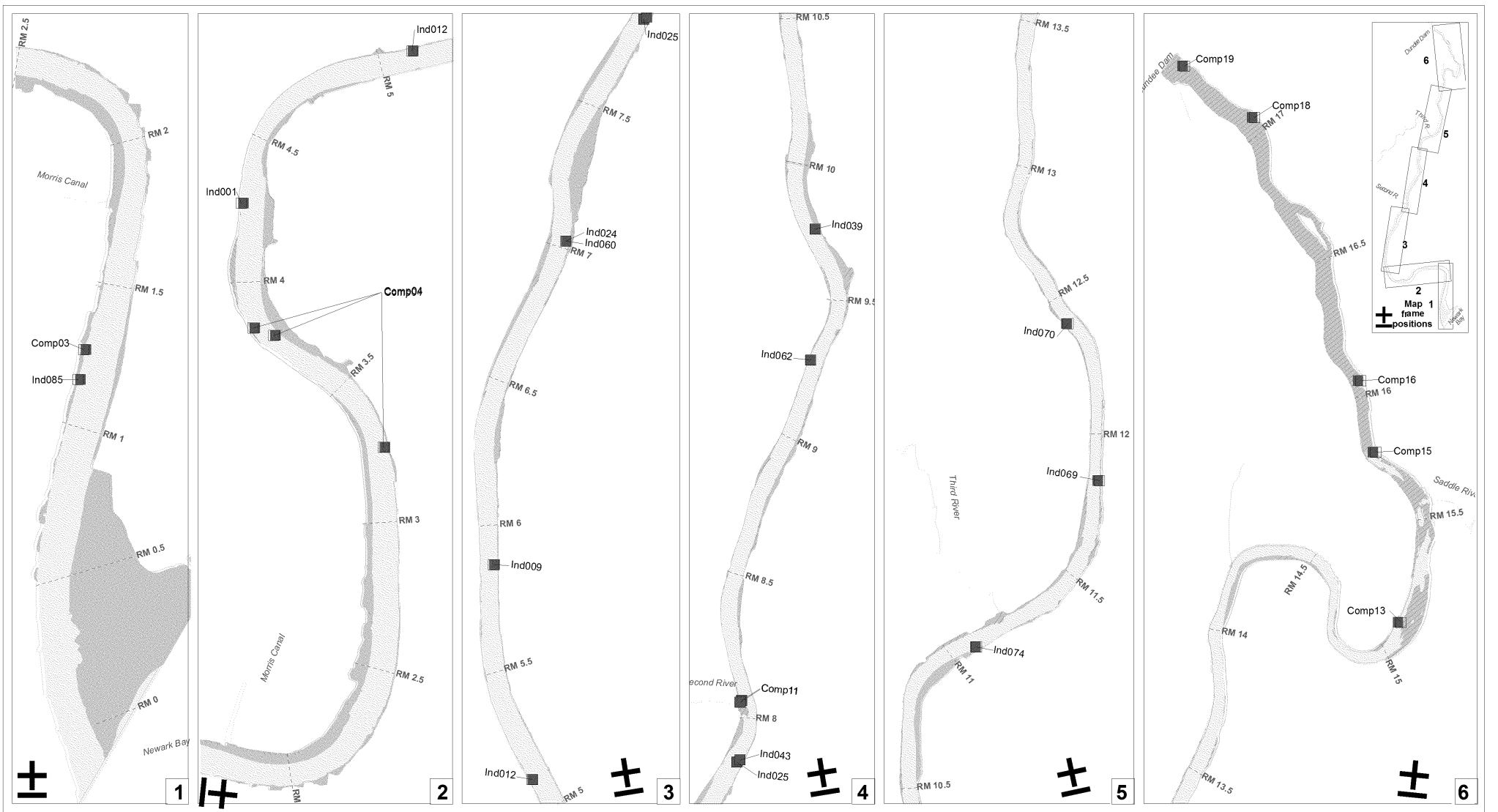
White perch - whole body
River mile
Mudflat
Gravel with fines
LPRSA

Mudflat areas for ecological receptors are those areas where the river bottom slope is ≤ 6° and the depth is ≥ -2 ft MLLW, based on the 2007 CPG bathymetric survey.

Figure 4-7. LPRSA locations for white perch tissue samples

DRAFT

Prepared by lindam 6/5/2014; W:\Projects\06-58-01 Passaic RI\Data\GIS\Maps_and_Analysis\BERA\4580_2009 perch tissue samples_CEH_20131111.mxd



0 0.5 Kilometers

0 0.25 Miles

- American eel - whole body
- River mile
- Mudflat
- Gravel with fines
- LPRSA

Mudflat areas for ecological receptors are those areas where the river bottom slope is ≤ 6° and the depth is ≥ -2 ft MLLW, based on the 2007 CPG bathymetric survey.

Figure 4-8. LPRSA locations for American eel tissue samples

DRAFT

Prepared by lindam 6/5/2014; W:\Projects\06-58-01 Passaic RI\Data\GIS\Maps_and_Analysis\BERA\4579_2009 eel tissue samples_CEH_20131111.mxd

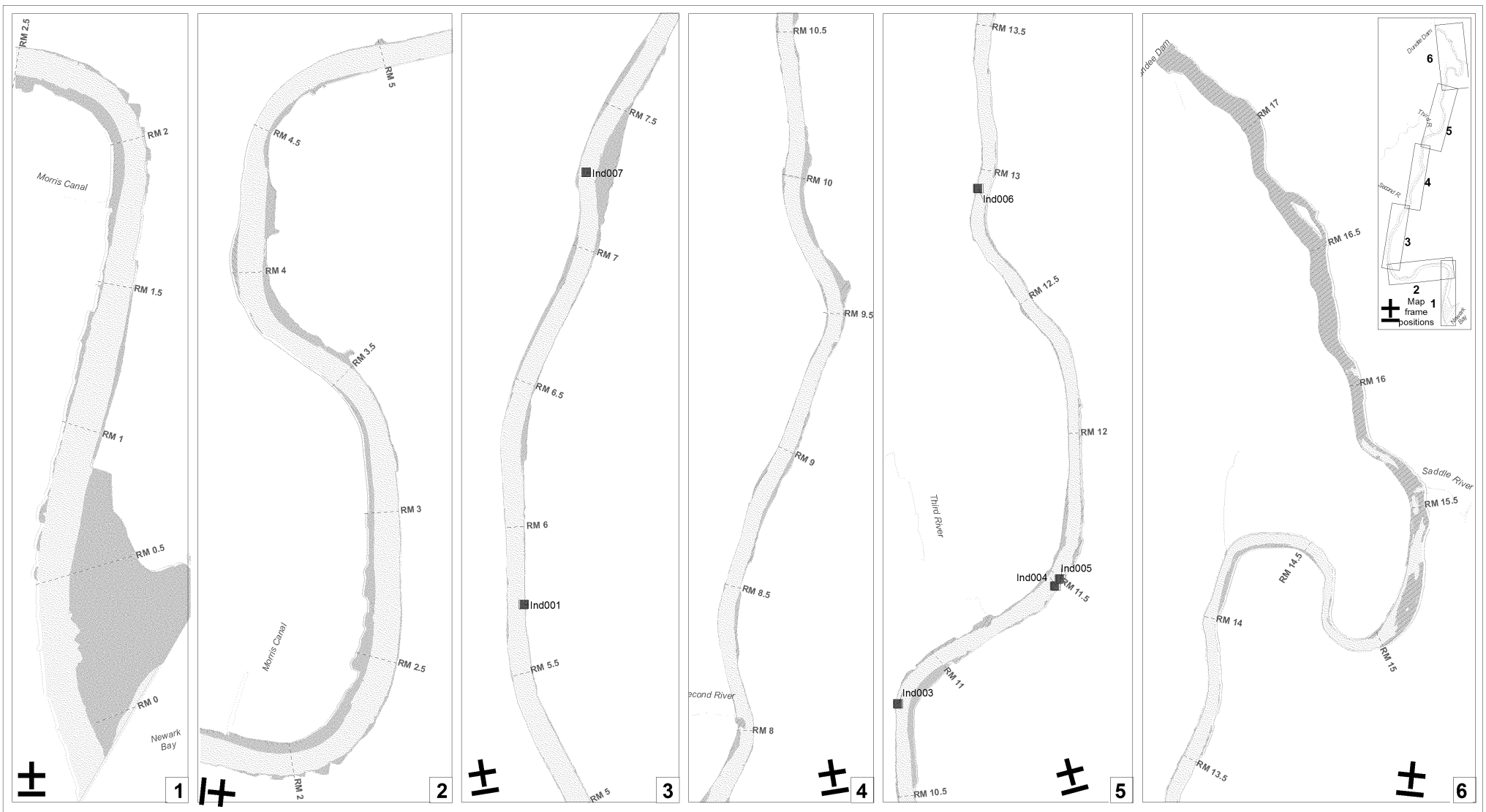


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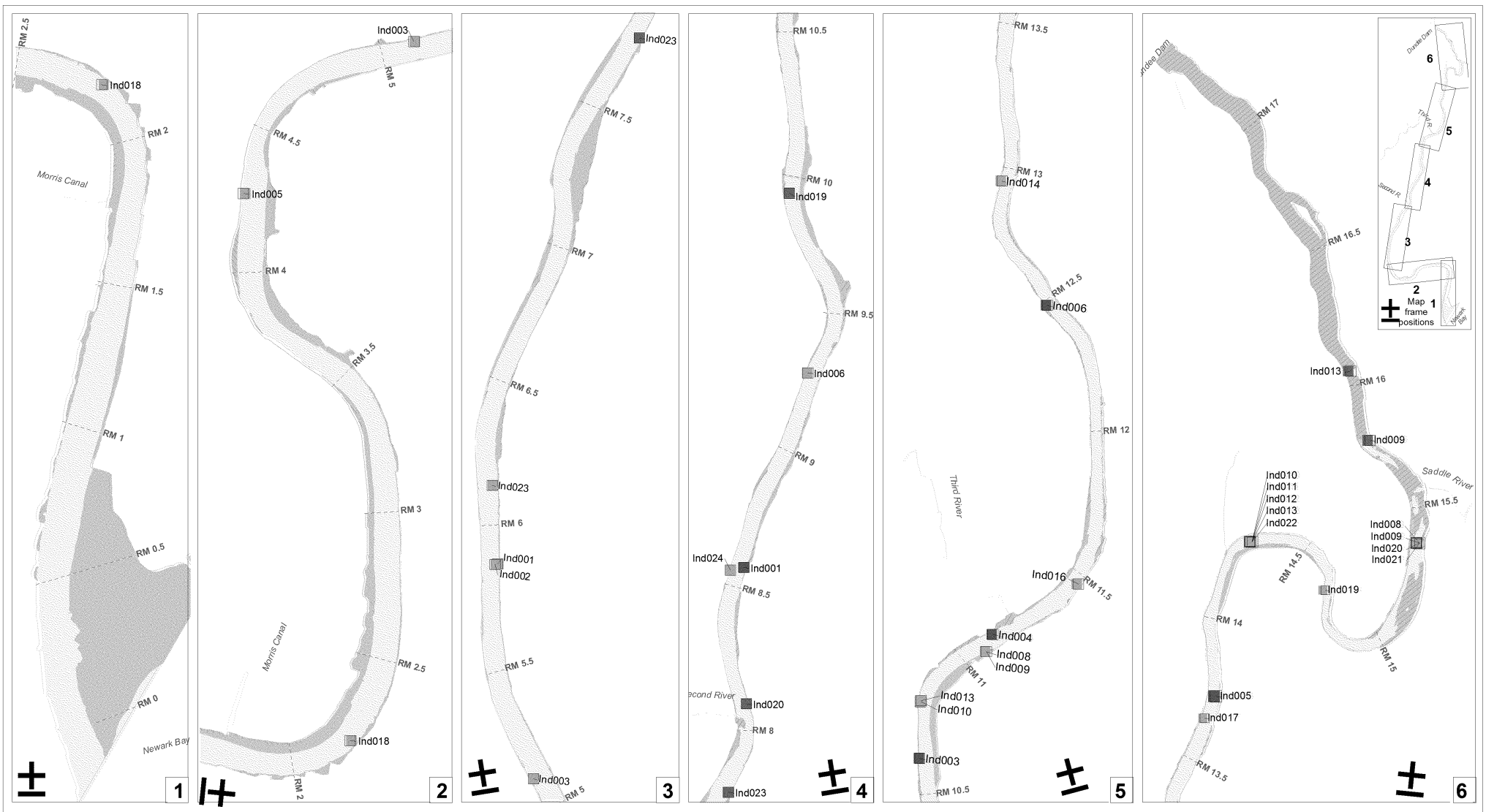
Figure 4-9. LPRSA locations for brown bullhead tissue samples

DRAFT

Prepared by lindam 6/5/2014; W:\Projects\06-58-01 Passaic RI\Data\GIS\Maps_and_Analysis\BERA\4069_Bullhead composite samples 2009_CEH_20131204.mxd



0 0.5 1 Kilometers

0 0.25 0.5 Miles

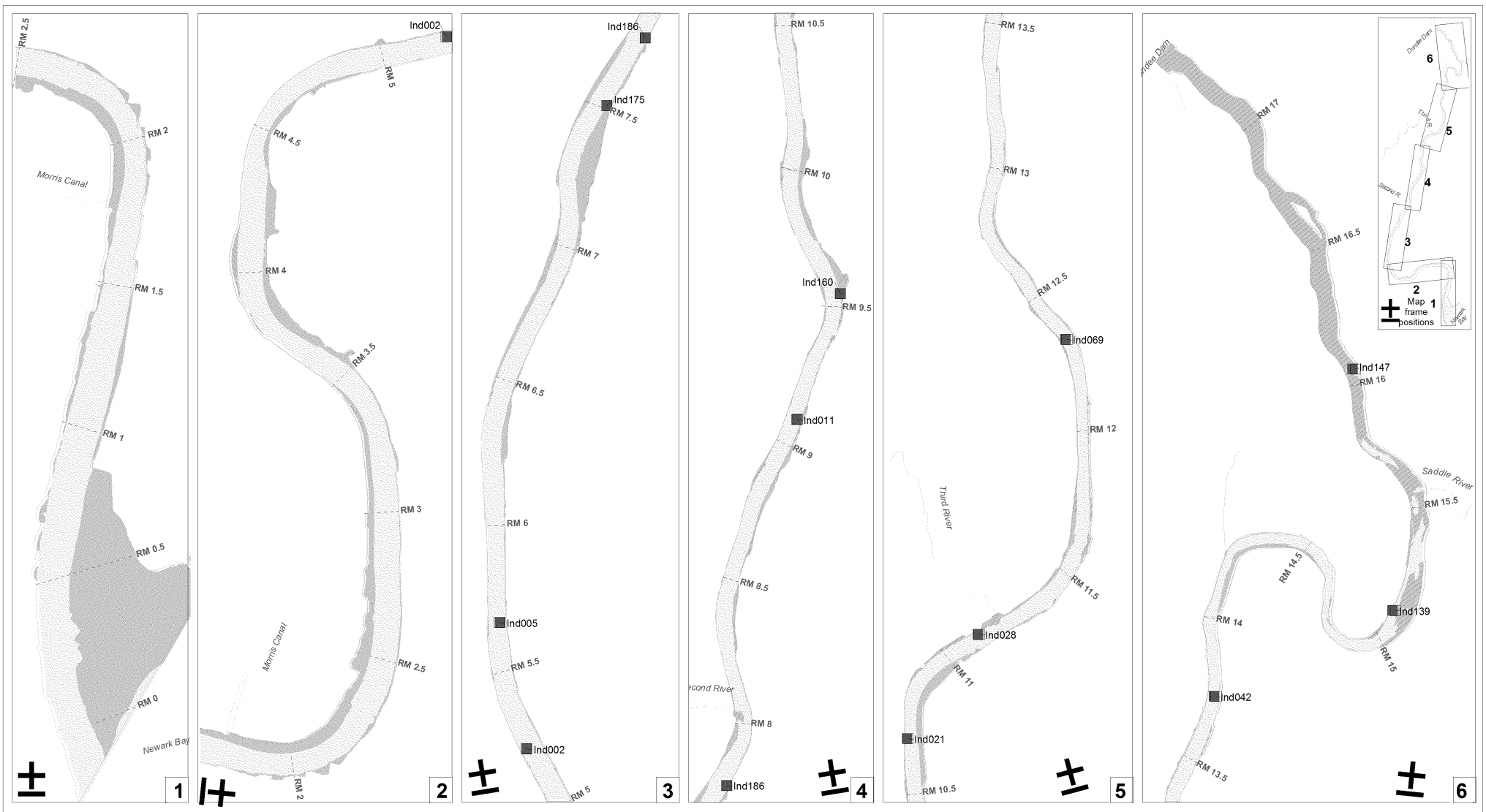
- Channel catfish - whole body
- White catfish - whole body
- White sucker - whole body
- River mile
- Mudflat
- Gravel with fines
- LPRSA

Mudflat areas for ecological receptors are those areas where the river bottom slope is ≤ 6° and the depth is ≥ -2 ft MLLW, based on the 2007 CPG bathymetric survey.

Figure 4-10. LPRSA locations for channel catfish, white catfish, and white sucker samples

DRAFT

Prepared by lindam 6/5/2014; W:\Projects\06-58-01 Passaic RI\Data\GIS\Maps_and_Analysis\BERA\4067_Catfish and sucker composite samples 2009_CEH_20131111.mxd



0 0.5 1 Kilometers

0 0.25 0.5 Miles

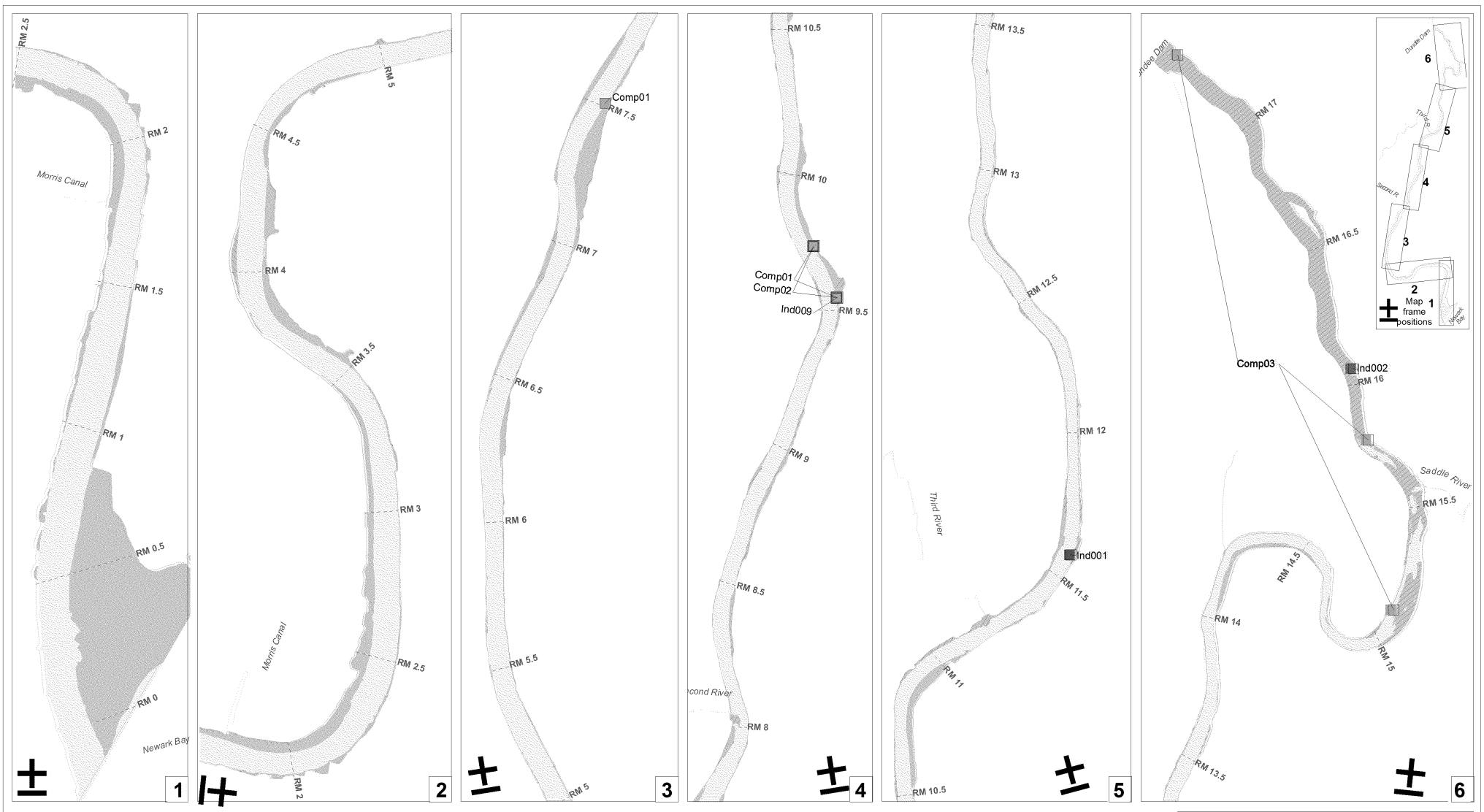
- Carp - whole body
- River mile
- Mudflat
- Gravel with fines
- LPRSA

Mudflat areas for ecological receptors are those areas where the river bottom slope is ≤ 6° and the depth is ≥ -2 ft MLLW, based on the 2007 CPG bathymetric survey.

Figure 4-11. LPRSA locations for carp samples

DRAFT

Prepared by lindam 6/5/2014; W:\Projects\06-58-01 Passaic RI\Data\GIS\Maps_and_Analysis\BERA\3978_Carp composite samples 2009_CEH_20131111.mxd



0 0.5 1 Kilometers

0 0.25 0.5 Miles

- Northern pike - whole body
- Smallmouth bass - whole body
- Largemouth bass - whole body
- River mile
- Mudflat
- Gravel with fines
- LPRSA

Mudflat areas for ecological receptors are those areas where the river bottom slope is ≤ 6° and the depth is ≥ -2 ft MLLW, based on the 2007 CPG bathymetric survey.

Figure 4-12. LPRSA locations for largemouth bass, smallmouth bass, and northern pike samples

DRAFT

Prepared by lindam 6/5/2014; W:\Projects\06-58-01 Passaic RI\Data\GIS\Maps_and_Analysis\BERA\4068_Bass and pike composite samples 2009_CEH_20131111.mxd

Figure 4-13. LPRSA locations for blue crab samples

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Prepared by lindam 6/5/2014; W:\Projects\06-58-01 Passaic RI\Data\GIS\Maps_and_Analysis\BERA\4632_2009 blue crab composites_CEH_20131111.mxd

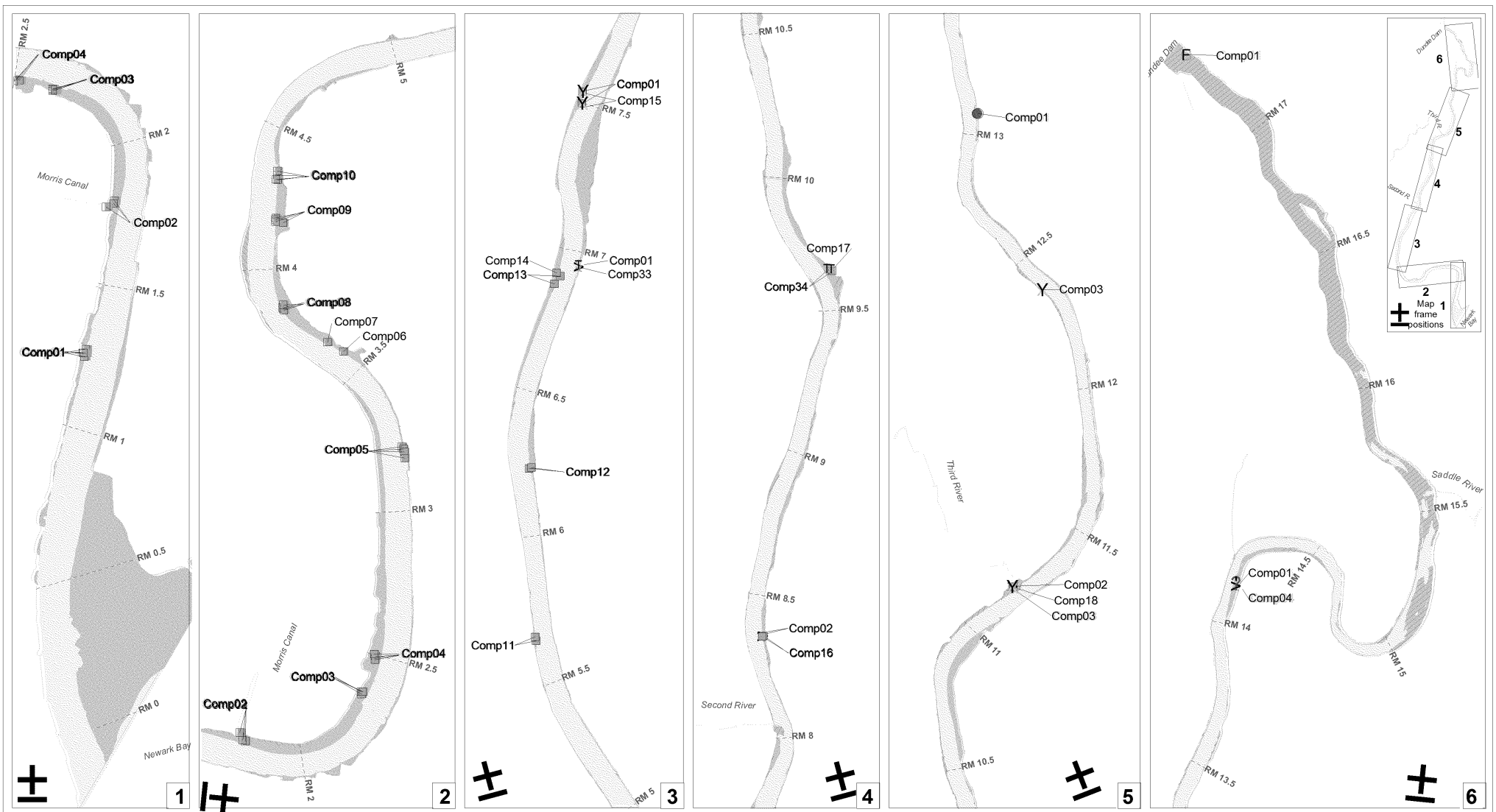


Figure 4-14. LPRSA locations for mummichog and other invertivore/omnivore samples

DRAFT

Prepared by lindam 6/5/2014; W:\Projects\06-58-01 Passaic RI\Data\GIS\Maps_and_Analysis\BERA\4703_Small forage fish 2010 composites catch locs LPR_LSM_20131205.mxd

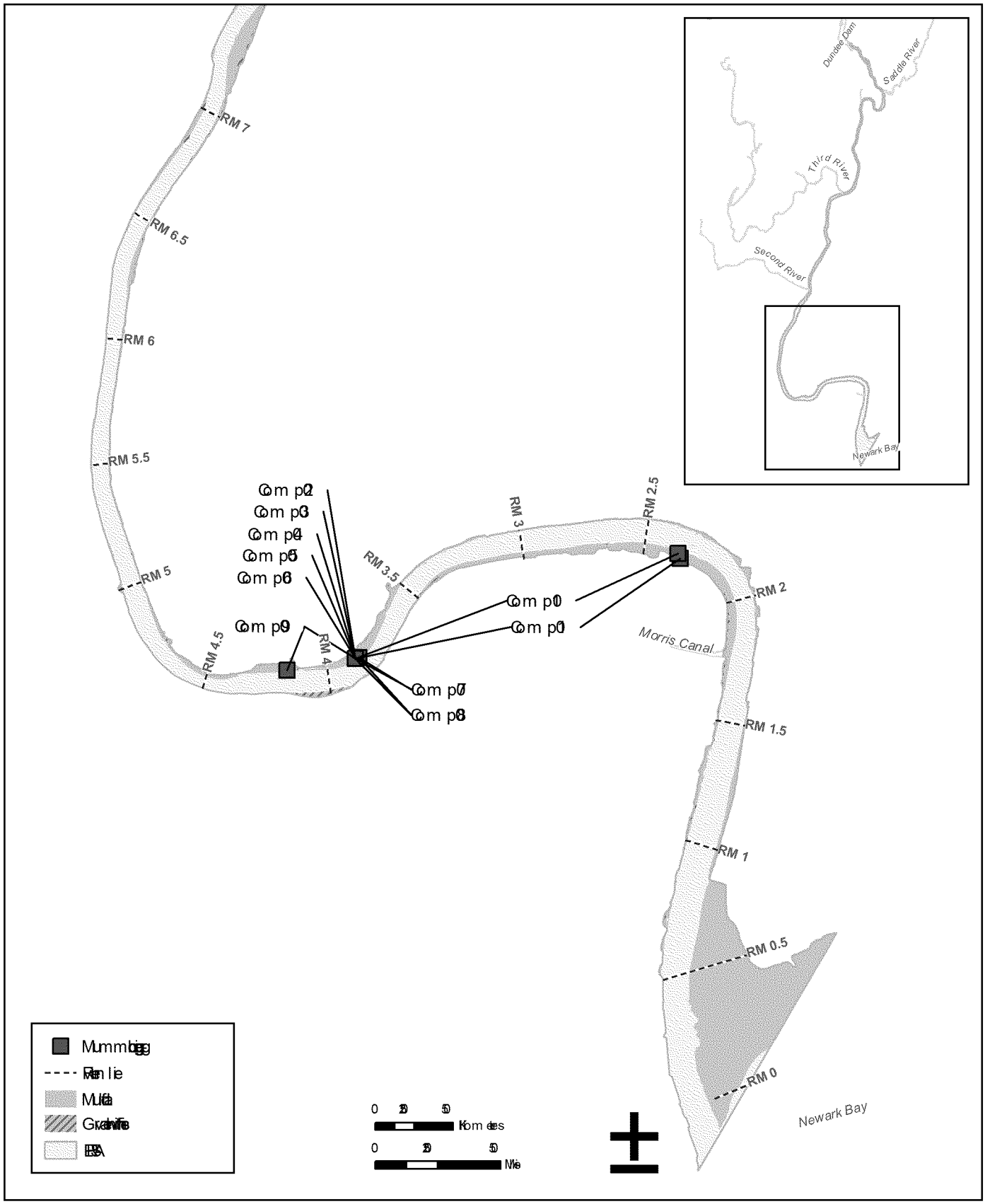


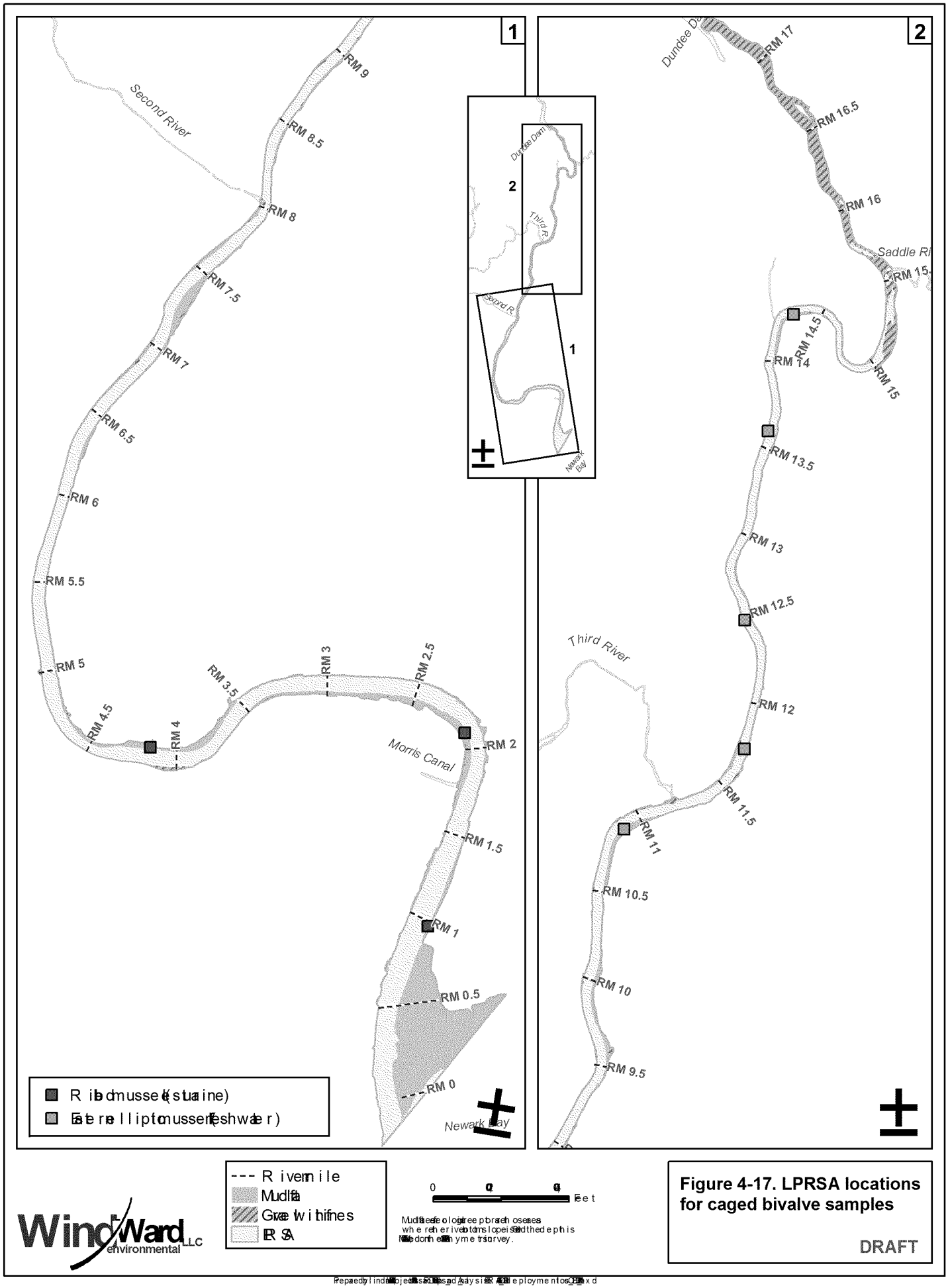
Figure 4-15. LPRSA locations for mummichog egg composite samples

DRAFT

Figure 4-16. LPRSA sediment locations for bioaccumulation samples

DRAFT

Prepared by lindam 6/5/2014; W:\Projects\06-58-01 Passaic RI\Data\GIS\Maps_and_Analysis\BERA\4582_Bioaccum surfc sed samples 2009-2010_LSM_20110405.mxd



FOIA_08606_0000092

1

RM 19.5

RM 19

RM 18.5

Comp01
Comp02
Comp03
Comp04
Comp05
Comp06

RM 18

Comp07

RM 17.4

Dundee Dam

2

RM 22

RM 21.5

RM 21

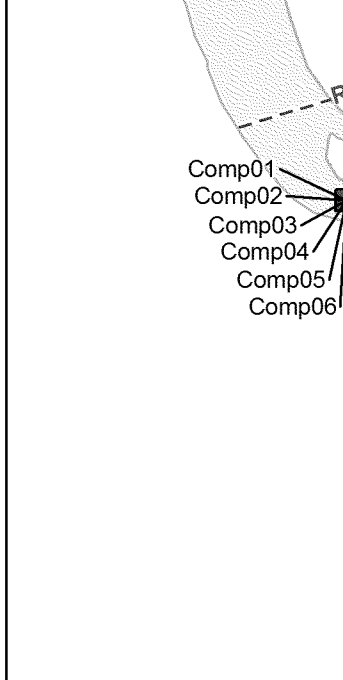
RM 20.5

RM 20

Comp08

RM 19.5

RM 19



White perch - whole body
River Mile
River
LPRSA

0 500 1,000 Feet

Data sources: river miles were derived from USGS NHD Streams.
Imagery from ESRI; http://goto.arcgisonline.com/maps/World_Imagery
Service Layer Credits:

Figure 4-18. Locations above Dundee Dam for white perch tissue samples

DRAFT

Prepared by CEH 6/4/2014; W:\Projects\06-58-01 Passaic RI\Data\GIS\Maps_and_Analysis\BERA\5406_Proposed UPR perch composites_CEH_20131111.mxd

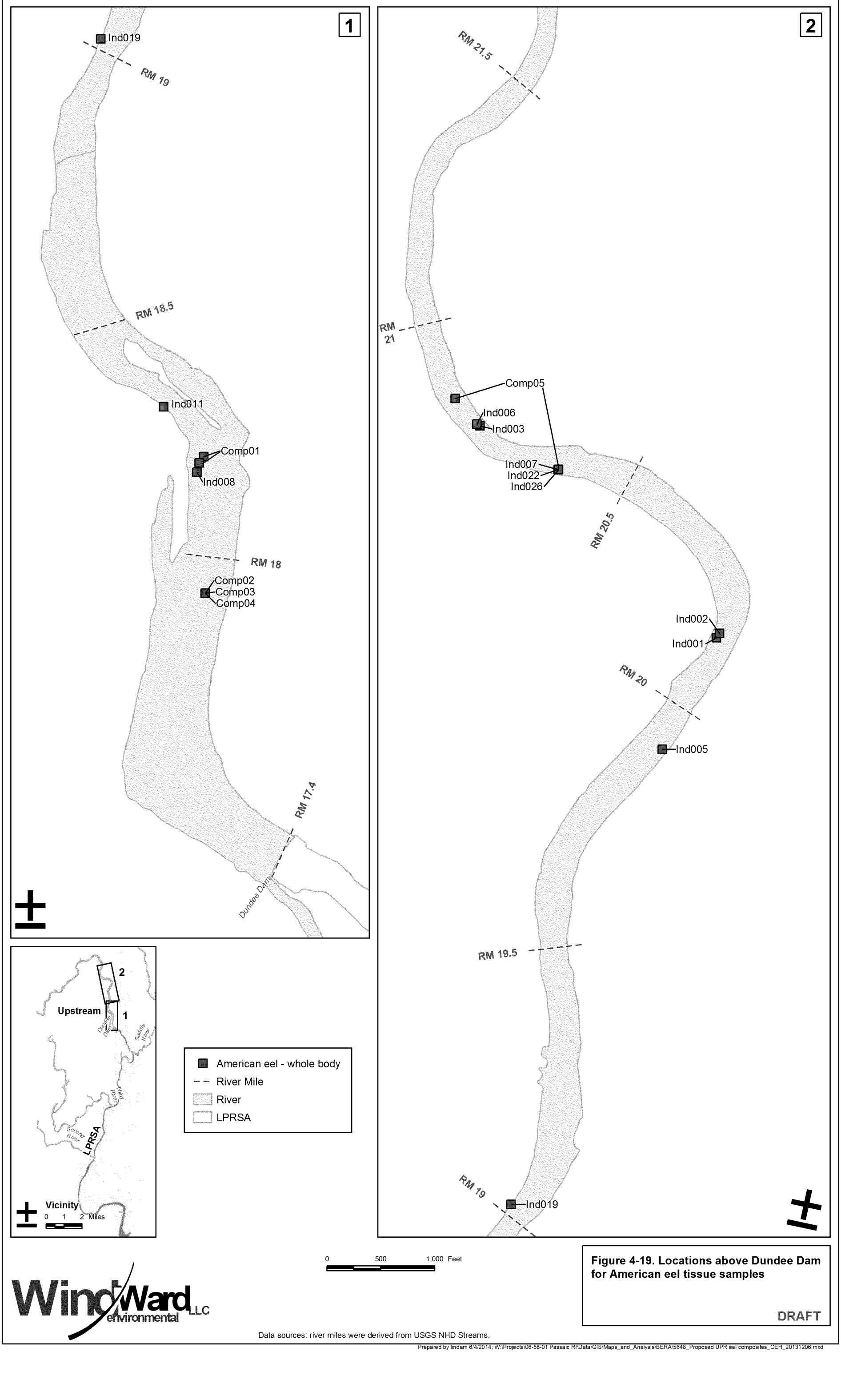


Figure 4-19. Locations above Dundee Dam for American eel tissue samples

DRAFT

Data sources: river miles were derived from USGS NHD Streams.

Prepared by lindam 6/4/2014; W:\Projects\06-58-01 Passaic RI\Data\GIS\Maps_and_Analysis\BERA\5648_Proposed UPR eel composites_CEH_20131206.mxd

1

RM 19

Ind043

RM 18.5

Ind055

RM 18

Ind040

RM 17.4

Dundee Dam

2

RM 21.5

RM 21

Ind050

RM 20.5

Ind006

RM 20

Ind004

RM 19.5

RM 19

Upstream

1

2

Dundee Dam

Saddle River

Third River

Second River

LPRSA

Vicinity

0 1 2 Miles

Brown bullhead - whole body

River Mile

River

LPRSA

0 500 1,000 Feet

Figure 4-20. Locations above Dundee Dam for brown bullhead tissue samples

DRAFT

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Data sources: river miles were derived from USGS NHD Streams.

Prepared by lindam 6/4/2014; W:\Projects\06-58-01 Passaic RI\Data\GIS\Maps_and_Analysis\BERA\5408_Proposed UPR bullhead composites_CEH_20131206.mxd

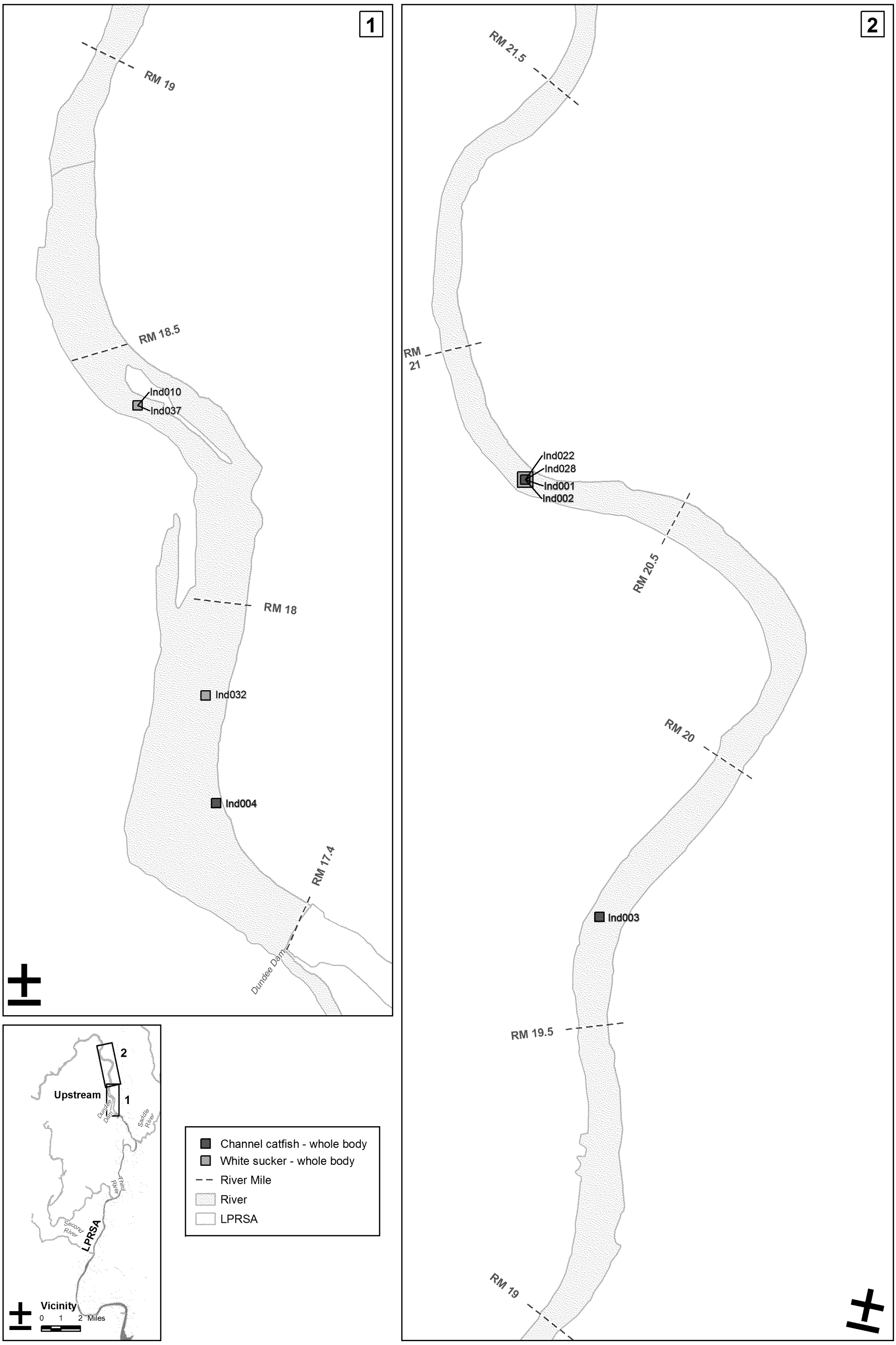


Figure 4-21. Locations above Dundee Dam for channel catfish and white sucker samples

DRAFT

Data sources: river miles were derived from USGS NHD Streams.

Prepared by lindam 6/4/2014; W:\Projects\06-58-01 Passaic RI\Data\GIS\Maps_and_Analysis\BERA\5409_Proposed UPR catfish and sucker composites_CEH_20131206.mxd

1

RM 19

RM 18.5

Ind011
Ind018
Ind016

RM 18

Ind001
Ind008
Ind003
Ind005
Ind007

RM 17.4

Dundee Dam

2

RM 21.5

RM 21

RM 20.5

RM 20

Ind028
Ind029

RM 19.5

RM 19

Upstream

1

2

Dundee Dam

Saddle River

Third River

Second River

LPRSA

Vicinity

0 1 2 Miles

Carp - whole body
River Mile
River
LPRSA

0 500 1,000 Feet

Figure 4-22. Locations above Dundee Dam for carp samples

DRAFT

WindWard environmental LLC

Data sources: river miles were derived from USGS NHD Streams.

Prepared by lindam 6/4/2014; W:\Projects\06-58-01 Passaic RI\Data\GIS\Maps_and_Analysis\BERA\5646_Proposed UPR carp composites_CEH_20131206.mxd

1

Comp01
RM 19
RM 18.5
RM 18
Comp02
Comp03
Comp01
Comp01
Comp01
RM 17.4
Dundee Dam

2

RM 21.5
RM
21
Comp01
RM 20.5
RM 20
Comp01
RM 19.5
RM 19
Comp01

Upstream
1
2
Dundee Dam
Saddle River
Third River
Second River
LPRSA

Vicinity
0 1 2 Miles

Smallmouth bass - whole body
Northern pike - whole body
River Mile
River
LPRSA

0 500 1,000 Feet

Figure 4-23. Locations above Dundee Dam for smallmouth bass and northern pike samples

DRAFT

WindWard environmental LLC

Data sources: river miles were derived from USGS NHD Streams.

Prepared by lindam 6/4/2014; W:\Projects\06-58-01 Passaic RI\Data\GIS\Maps_and_Analysis\BERA\5411_Proposed UPR smm bass and pike composites_LSM_20131206.mxd

1

RM 19

RM 18.5

RM 18

RM 17.4

Dundee Dam

2

RM 21.5

RM 21

Comp01

RM 20.5

RM 20

RM 19.5

Comp01

Comp01

RM 19

Upstream

2

1

LPRSA

Vicinity

0 1 2 Miles

Banded killifish - whole body
Pumpkinseed - whole body
Silver shiner - whole body
River Mile
River
LPRSA

0 500 1,000 Feet

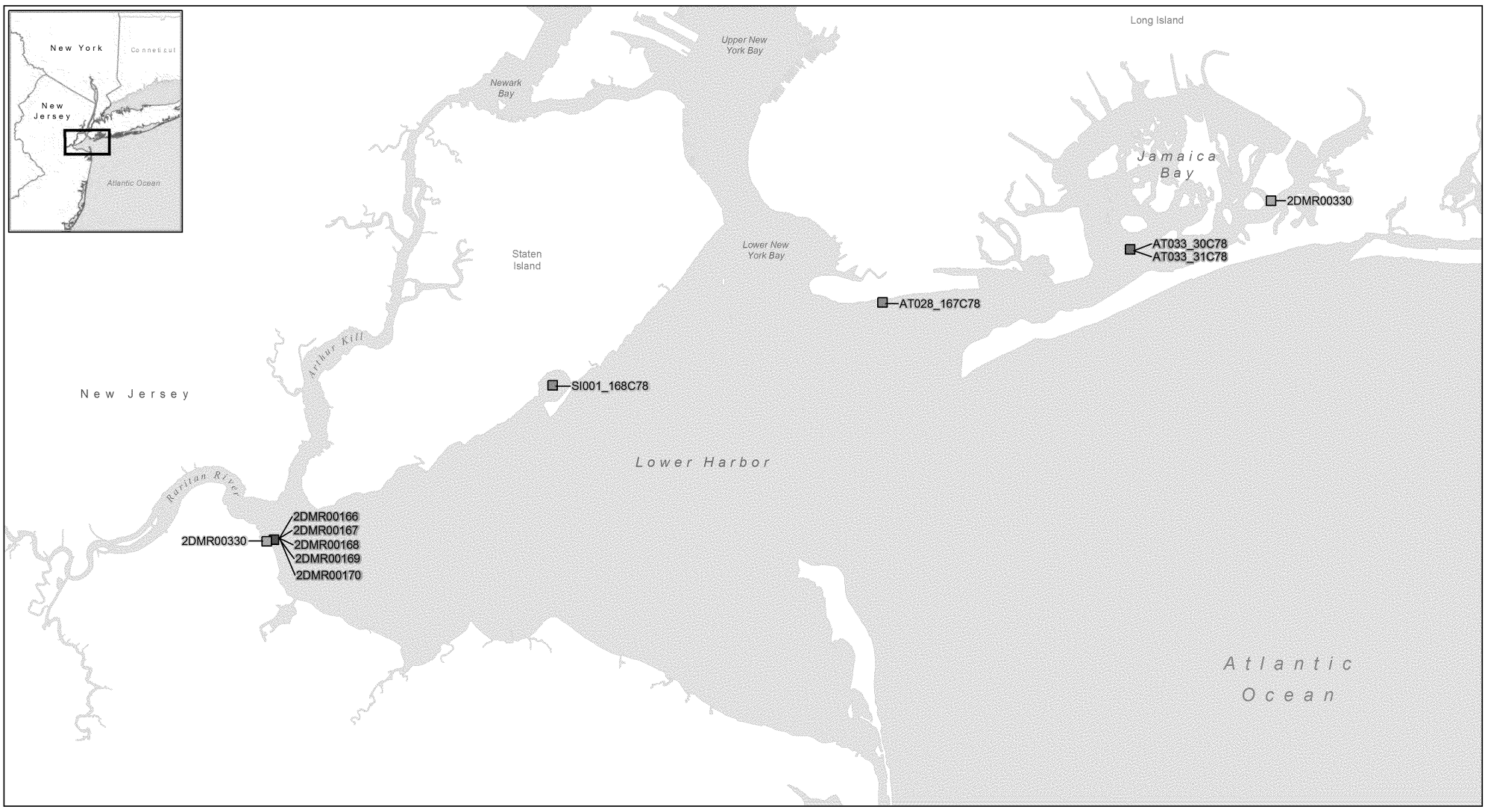
Figure 4-24. Locations above Dundee Dam for small forage fish samples

DRAFT

WindWard environmental LLC

Data sources: river miles were derived from USGS NHD Streams.

Prepared by lindam 6/4/2014; W:\Projects\06-58-01 Passaic RI\Data\GIS\Maps_and_Analysis\BERA\5405_Locations above Dundee Dam for small forage fish samples_MTY_20131206.mxd



WindWard LLC environmental

0 1 2 Kilometers

0 1 2 Miles

Mummichog - whole body
- Summer 1999 Harbor Fish Collection
- Fall 1999 Harbor Fish Collection

Banded killifish - whole body
- NYSDEC 1978

Other killifish - whole body
- NYSDEC 1978

Figure 4-25. Jamaica Bay and Lower Harbor locations for mummichog and killifish samples

DRAFT

Prepared by lindam 6/4/2014; W:\Projects\06-58-01 Passaic RI\Data\GIS\Maps_and_Analysis\BERA\5729_Jamaica Bay and Lower Harbor locs for killifish species_MTY_20131202.mxd

WindWard LLC environmental

0 1 2 Kilometers

0 1 2 Miles

±

Mummichog - whole body
1999 Late Summer/Early Fall RI-ESP Sampling Program
2000 Spring RI-ESP Sampling Program

Figure 4-26. Mullica River and Great Bay locations for mummichog samples

DRAFT

Prepared by lindam 6/4/2014; W:\Projects\06-58-01 Passaic RI\Data\GIS\Maps_and_Analysis\BERA\5730_Mullica River and Great Bay mummichog locs_MTY_20131203.mxd

4.2.4 Surface water chemistry data

Surface water chemistry data used in the BERA (Table 4-4) were for LPRSA samples collected during the following sampling events:

- Four routine chemical water column monitoring events in 2011 and 2012 (Figure 4-27) under normal flow conditions (i.e., 400 to 3,000 cubic feet per second [cfs] at Dundee Dam) (AECOM 2011c), as follows:
  - Event 1 was conducted August 15 to 17, 2011, during average tide (median flow at Dundee Dam was 2,650 cfs).
  - Event 2 was conducted February 20 to 21, 2012, during spring tide (median flow at Dundee Dam was 699 cfs).
  - Event 3 was conducted March 26 to 27, 2012, during neap tide[40] (median flow at Dundee Dam was 392 cfs).
  - Event 4 was conducted June 4 to 5, 2012, during spring tide (median flow at Dundee Dam was 1,389 cfs).
- A single low-flow (i.e., < 400 cfs at Dundee Dam) water column monitoring event in August 2012 during spring tide(median flow at Dundee Dam was 253 cfs) (Figure 4-27)

At each location from RM 0 to RM 10.2 and during every sampling event, grab samples were collected from two depths in the water column: 3 ft (0.9 m) above the bottom and 3 ft (0.9 m) below the surface. Samples were collected at four intervals (i.e., high water slack tide, low water slack tide, maximum ebb tide and maximum flood tide) at each location and depth.

LPRSA water chemistry data collected after the summer of 2012 were excluded from the BERA dataset because validated data were not available prior to conducting the LPRSA SLERA (Appendix A). The BERA water chemistry dataset (five sampling events) was compared to the BERA dataset with data from the chemical water column monitoring event in 2012 (Event 5) and the two high flow events in 2013 (eight sampling events) in Appendix K. Mean concentrations of the surface water COPECs were similar between the two datasets with an average relative percent difference of 11.5% (Appendix K). Based on this comparison, the use of the data from the five chemical water column sampling events as the basis for the BERA surface water evaluation is not expected to underestimate current risks.

The background dataset was developed using surface water chemistry samples collected in 2011 and 2012 from one location above Dundee Dam during the four routine monitoring events detailed above (Figure 4-27).

[40] The period of neap tide started on the last day of sampling, when the boats were in Newark Bay.

Table 4-4. Surface water data included in the BERA dataset

Sampling Event	Sampling Period	Description	Number of Locations	Chemical Group	Source
LPRSA					
2011 chemical water column monitoring	August 2011	surface water collection during average tide	5	total and dissolved metals, butyltins, PAHs, alkylated PAHs, SVOCs, PCB congeners, PCDDs/PCDFs, organochlorine pesticides, VOCs, cyanide, DOC, POC, TOC, TDS, chlorophyll-a, and water quality parameters	ddms (2013a)
2012 chemical water column monitoring 2	February 2012	surface water collection during spring tide	5	total and dissolved metals, PCB congeners, PCDDs/PCDFs, DOC, POC, TOC, TDS, chlorophyll-a, and water quality parameters	ddms (2013c)
2012 chemical water column monitoring 3	March 2012	surface water collection during neap tide[a]	5	total and dissolved metals, butyltins, PAHs, alkylated PAHs, SVOCs, PCB congeners, PCDDs/PCDFs, organochlorine pesticides, VOCs, cyanide, DOC, POC, TOC, TDS, chlorophyll-a, and water quality parameters	ddms (2013d)
2012 chemical water column monitoring 4	June 2012	surface water collection during spring tide	5	total and dissolved metals, PCB congeners, PCDDs/PCDFs, DOC, POC, TOC, TDS, and chlorophyll-a, and water quality parameters	ddms (2013e)
2012 low-flow chemical water column monitoring	August 2012	surface water collection during low flow	5	total and dissolved metals, butyltins, PAHs, SVOCs, alkylated PAHs, PCB congeners, PCDDs/PCDFs, organochlorine pesticides, VOCs, cyanide, DOC, POC, TOC, TDS, chlorophyll-a, and water quality parameters	ddms (2013f)
Passaic River above Dundee Dam					
2011 chemical water column monitoring	August 2011	surface water collection during average tide	1	total and dissolved metals, butyltins, PAHs, alkylated PAHs, SVOCs, PCB congeners, PCDDs/PCDFs, organochlorine pesticides, VOCs, cyanide, DOC, POC, TOC, TDS, chlorophyll-a, and water quality parameters	ddms (2013a)
2012 chemical water column monitoring 2	February 2012	surface water collection during spring tide	1	total and dissolved metals, PCB congeners, PCDDs/PCDFs, DOC, POC, TOC, TDS, chlorophyll-a, and water quality parameters	ddms (2013c)
2012 chemical water column monitoring 3	March 2012	surface water collection during neap tide[a]	1	total and dissolved metals, butyltins, PAHs, alkylated PAHs, SVOCs, PCB congeners, PCDDs/PCDFs, organochlorine pesticides, VOCs, cyanide, DOC, POC, TOC, TDS, chlorophyll-a, and water quality parameters	ddms (2013d)
2012 chemical water column monitoring 4	June 2012	surface water collection during spring tide	1	total and dissolved metals, PCB congeners, PCDDs/PCDFs, DOC, POC, TOC, TDS, and chlorophyll-a, and water quality parameters	ddms (2013e)

Table 4-4. Surface water data included in the BERA dataset

Sampling Event	Sampling Period	Description	Number of Locations	Chemical Group	Source
2012 low-flow chemical water column monitoring	August 2012	surface water collection during low flow	1	total and dissolved metals, butyltins, PAHs, SVOCs, alkylated PAHs, PCB congeners, PCDDs/PCDFs, organochlorine pesticides, VOCs, cyanide, DOC, POC, TOC, TDS, chlorophyll-a, and water quality parameters	ddms (2013f)

[a] The period of neap tide started on the last day of sampling, when the boats were in Newark Bay.

BERA – baseline ecological risk assessment
DOC – dissolved organic carbon
LPRSA – Lower Passaic River Study Area
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
PCDD – polychlorinated dibenzo-*p*-dioxin
PCDF – polychlorinated dibenzofuran
POC – particulate organic carbon
SVOC – semivolatile organic compound
TDS – total dissolved solids
TOC – total organic carbon
VOC – volatile organic compound

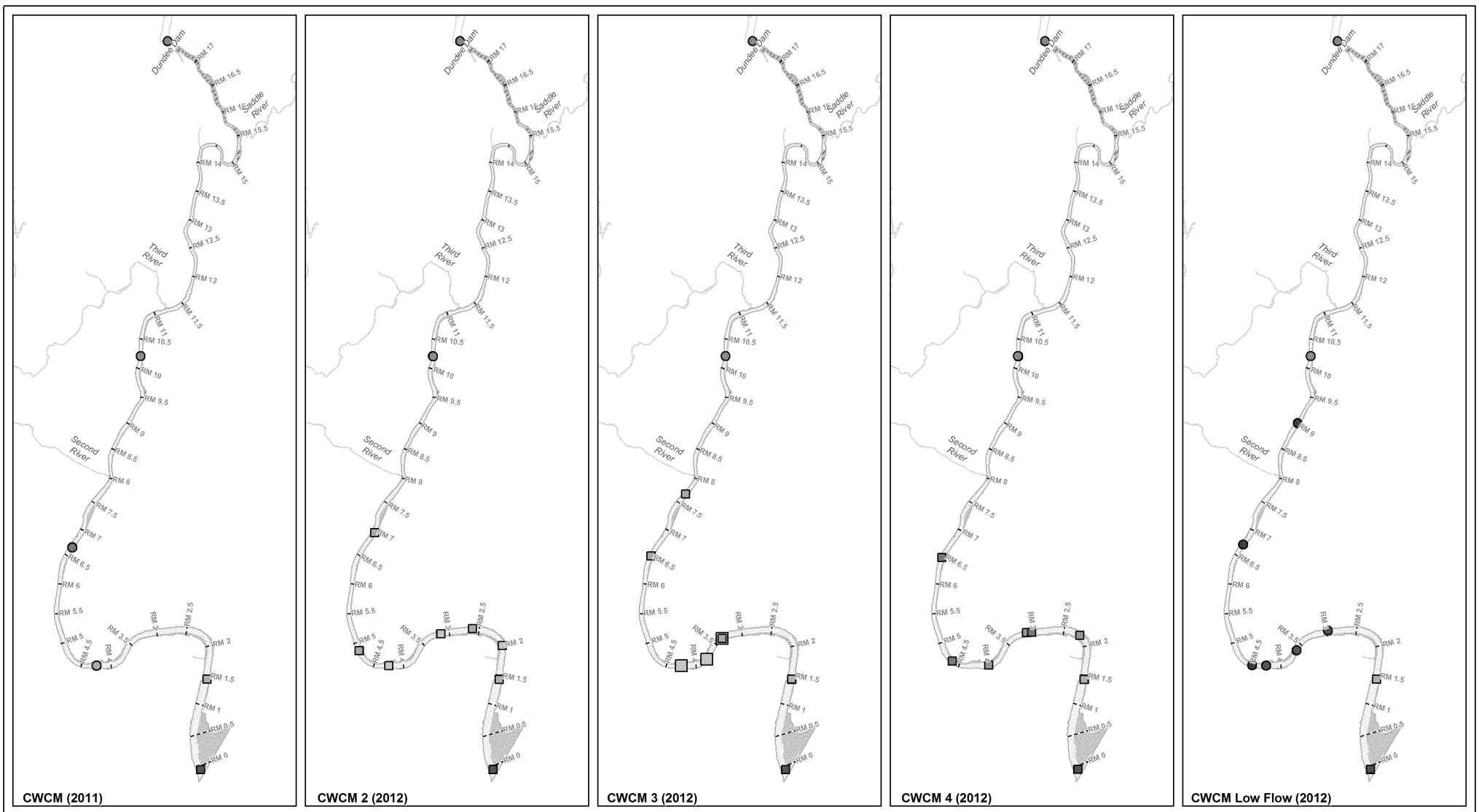


Figure 4-27. LPRSA locations and above Dundee Dam locations for surface water chemistry samples

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4.2.5 Biological survey data

Survey data were collected to provide qualitative information about fish and avian communities, as well as the shoreline habitat in and water quality of the LPRSA (Table 4-5). These data were used in the BERA to provide additional information in the evaluation of potential risks and the overall health of ecological receptors. Benthic invertebrate community survey data were also collected for use in the SQT analysis.

Data from the following surveys conducted within the LPRSA were included in the BERA:

- Seasonal fish community surveys, including the evaluation of external and internal gross pathology from 2009 to 2010 (sampling methods and locations are shown in Figures 4-28 to 4-31)
- Benthic invertebrate community surveys conducted in 2009 and 2010 using surface sediment from the locations shown in Figure 4-32[41]
- Seasonal avian community surveys from 2009 to 2011 (Figure 4-33)
- A habitat survey of the LPRSA and select tributary shoreline features and vegetation conducted in 2010
- Continuous near-bottom (i.e., 8 in. [0.2 m] above bottom) DO monitoring conducted at 11 LPRSA locations in 2012 (Figure 4-34)

Survey data were collected above Dundee Dam to provide qualitative background and reference information about the fish community and water quality and to provide reference information for the benthic invertebrate community in the freshwater portion of the LPRSA. Data from the following surveys conducted above Dundee Dam were included in the BERA:

- A fish community survey, including the evaluation of gross pathology, conducted in October 2012 (sampling methods and locations are shown in Figures 4-35 and 4-36)
- Continuous near-bottom DO monitoring conducted at two locations above Dundee Dam in 2012 (Figure 4-34)
- A benthic invertebrate community survey conducted in 2012 using surface sediment from the SQT (analyzed for chemistry and toxicity) sediment samples (Figure 4-4)

Regional reference information also included benthic invertebrate community survey data collected from 1993 to 1998 from multiple locations in Jamaica Bay and from 1995

[41] The 2009 fall benthic invertebrate community survey was conducted using SQT sediment samples that were analyzed for chemistry and toxicity (Figure 4-5).

to 2006 from multiple locations in Mullica River and Great Bay (Figures 4-37 and 4-38, respectively).

Table 4-5. Biological survey data included in the BERA dataset

Sampling Event	Survey Period	Description	Source
LPRSA			
Fish community seasonal surveys	August to September 2009 (late summer/early fall)	surveys of the fish community, including gross internal and external pathology evaluations on select fish	Windward (2010c)
	January to February 2010 (winter)		Windward (2011c)
	June to July 2010 (late spring/early summer)		
Benthic invertebrate community seasonal surveys	October to November 2009 (fall)	benthic invertebrate community data from surface sediment grab samples (0 to 15 cm) at 100 locations	Windward (2014a)
	June 2010 (spring)	benthic invertebrate community data from surface sediment grab samples (0 to 15 cm) at 33 locations	Windward (2014c)
	July to August 2010 (summer)	benthic invertebrate community data from surface sediment grab samples (0 to 15 cm) at 33 locations	
Avian community seasonal surveys	August 2010 (summer)	qualitative survey of birds observed in habitats using transects that were surveyed a total of three times (i.e., at sunrise, midday, and sunset)	Windward (2011a)
	October 2010 (fall)		
	January 2011(winter)		Windward ([in prep]-j)
	May 2011 (spring)		
Habitat survey	September 2010	qualitative survey of shoreline features and vegetation within the LPRSA and LPRSA tributaries	Windward (2010d)
DO monitoring	August 7 to December 9, 2012	continuous near-bottom (i.e., 8 in. above bottom) monitoring for DO, temperature, turbidity, and salinity at 11 locations	Windward ([in prep]-k)
Passaic River Above Dundee Dam			
Fish community survey	October 2012	survey of the fish community; gross internal and external pathology evaluations on select fish	Windward ([in prep]-g)
Benthic invertebrate community survey	November 2012	benthic invertebrate community data from surface sediment grab samples(0 to 15 cm) at 24 locations	Windward ([in prep]-f); (Windward 2014b)
DO monitoring	August 7 to December 9, 2012	continuous near-bottom (i.e., 8 in. above bottom) monitoring for DO, temperature, turbidity, and salinity at two locations	(Windward [in prep]-g)
Jamaica Bay			
1993 to 1998 REMAP	September 1993 to August 1998	benthic invertebrate community data from 56 surface sediment grab samples (0 to 15 cm) collected from Jamaica Bay (samples were co-located with chemistry analysis and toxicity testing)	USEPA (2011b)

Table 4-5. Biological survey data included in the BERA dataset

Sampling Event	Survey Period	Description	Source
Mullica River/Great Bay Estuary and Mullica River Freshwater Area			
2000 to 2002 EMAP	September 2000 to September 2002	benthic invertebrate community data from surface sediment grab samples (0 to 15 cm) collected from Mullica River and Great Bay	USEPA (2011b)
1995 to 2006 NCA Program New Jersey Atlantic Coast	February 1995 to April 2006	benthic invertebrate community data from surface sediment grab samples (0 to 15 cm) collected from Mullica River and Great Bay	USEPA (2011b)

BERA – baseline ecological risk assessment
DO – dissolved oxygen
EMAP – Environmental Monitoring and Assessment Program
LPRSA – Lower Passaic River Study Area
NCA – National Coastal Assessment
POC – particulate organic carbon
REMAP – Regional Environmental Monitoring and Assessment Program
USEPA – US Environmental Protection Agency

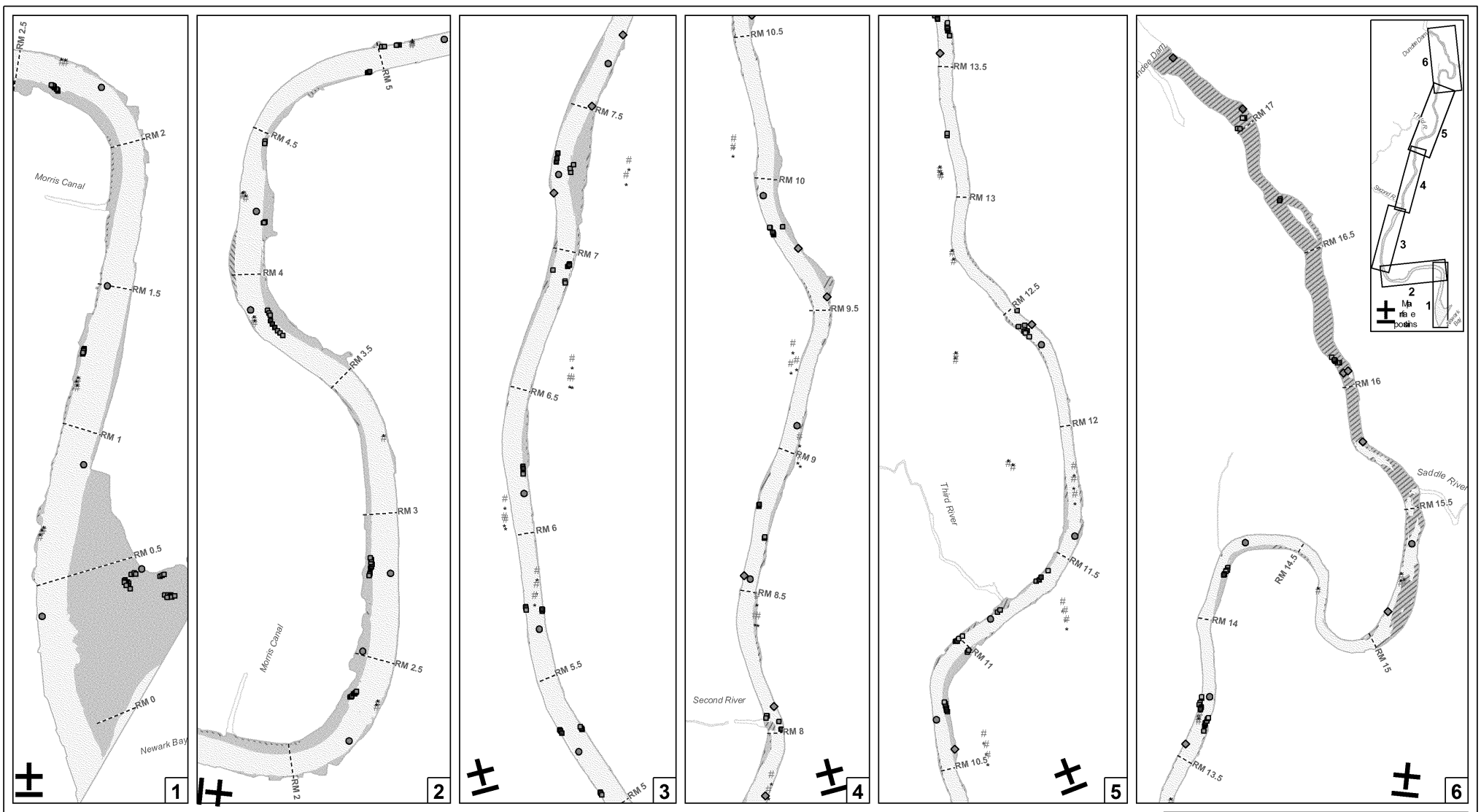

Figure 4-28. LPRSA locations where specimens were collected during the late summer/early fall 2009 fish community survey

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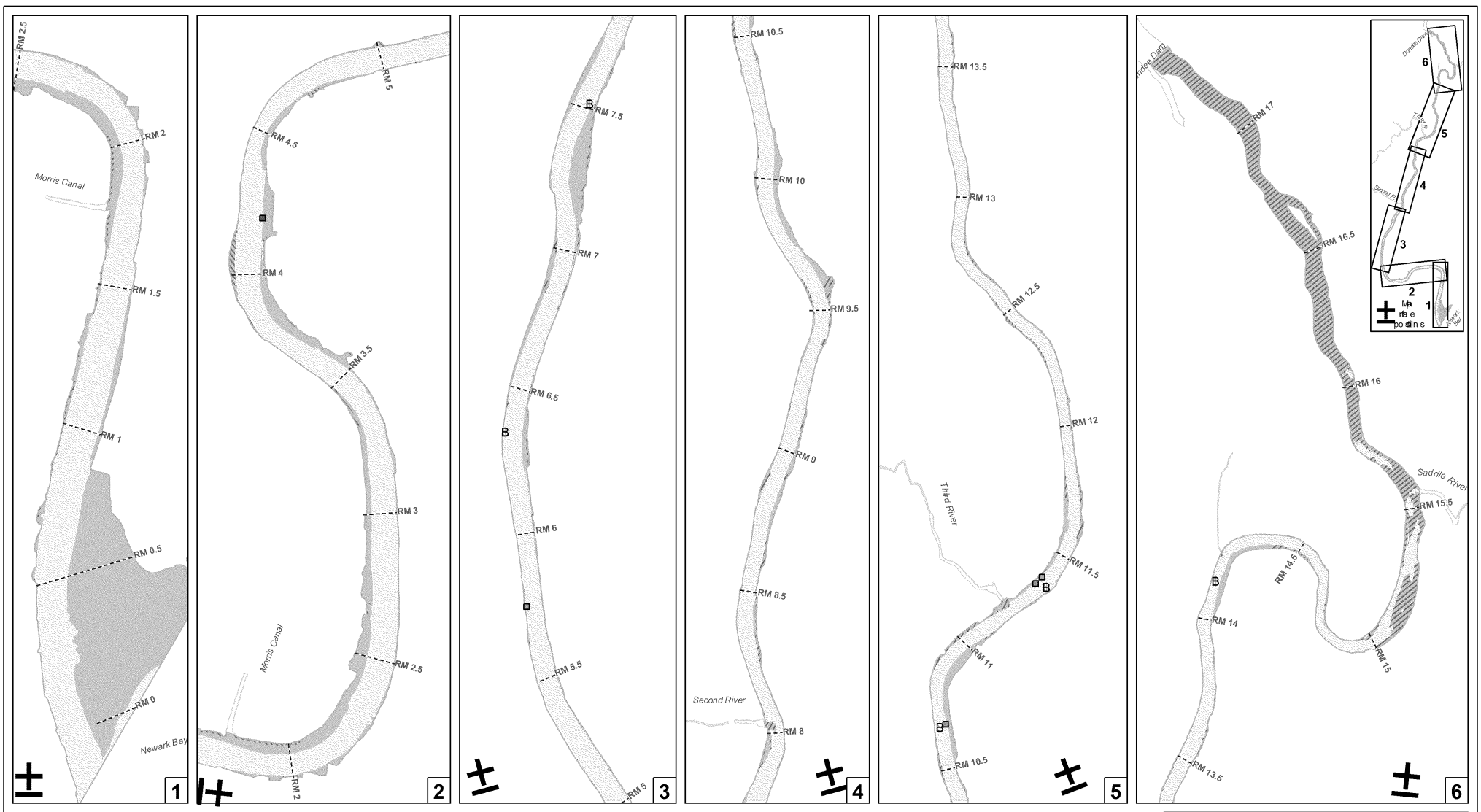

0 5 10 Kilometers

0 2.5 5 Miles

B Catch
Extra
Effort
Main stem
Main
Gradient
DMS

Figure 4-29. LPRSA locations where specimens were collected during the winter 2010 fish community survey

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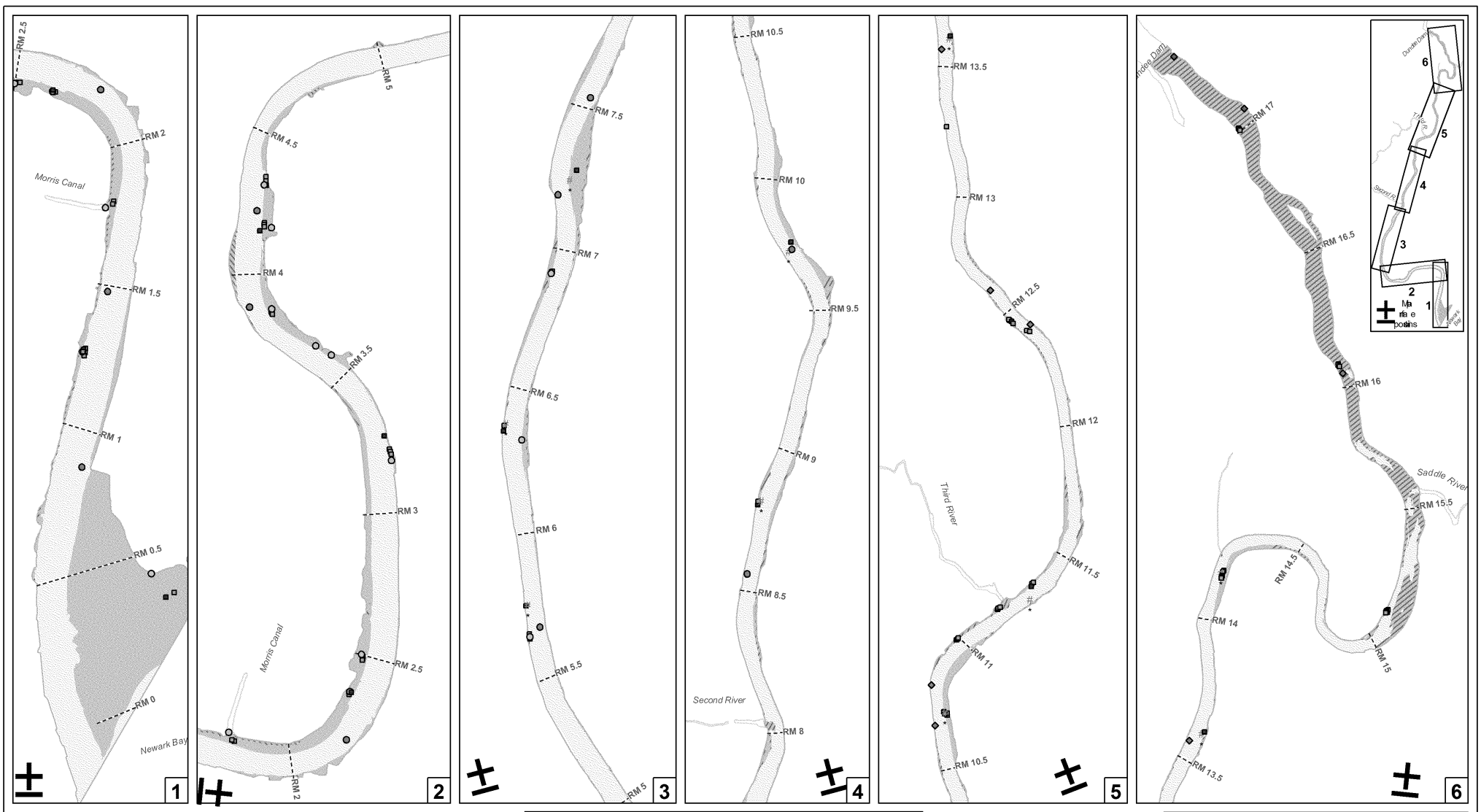

Figure 4-30. LPRSA locations where specimens were collected during the late spring/early summer 2010 fish community survey

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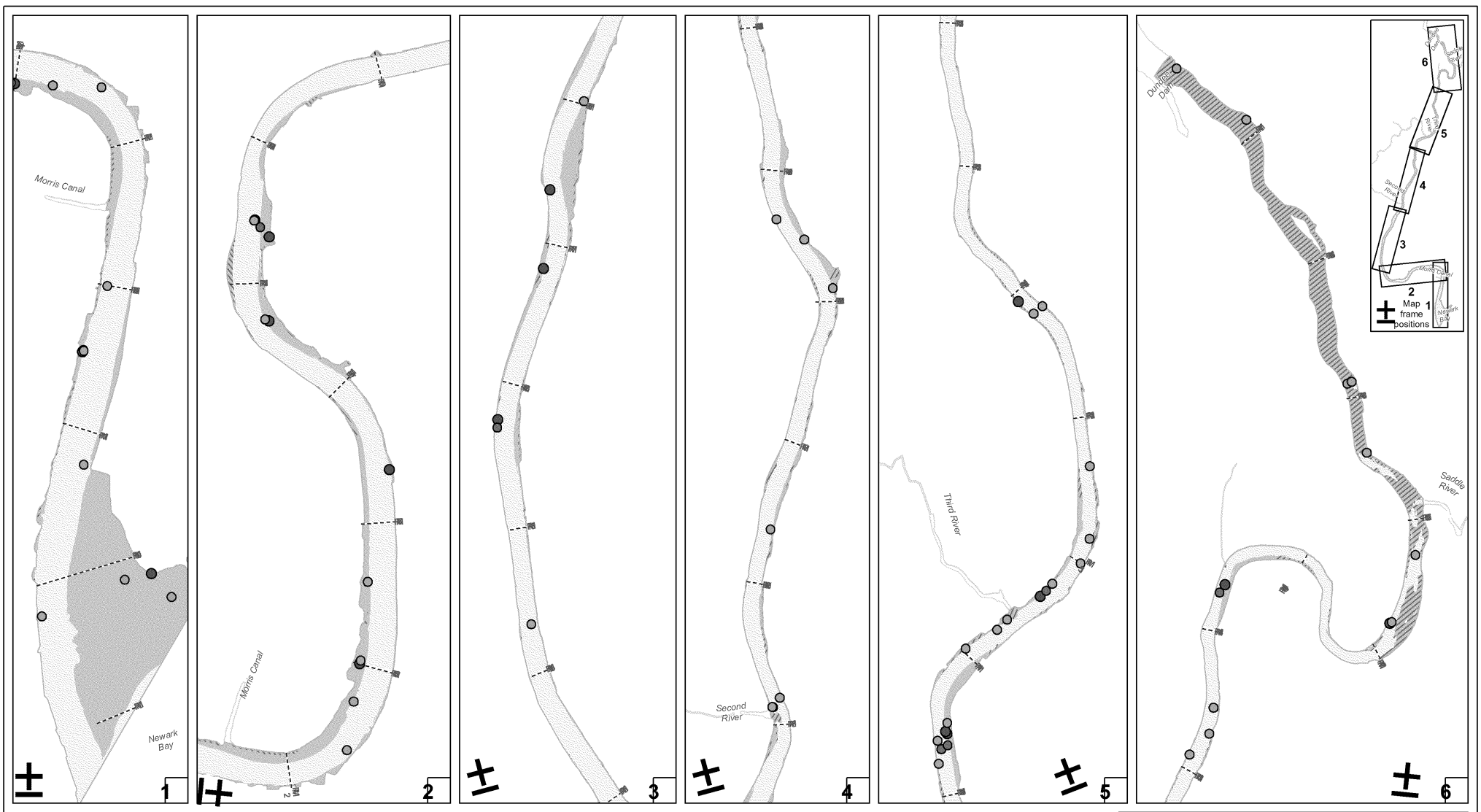

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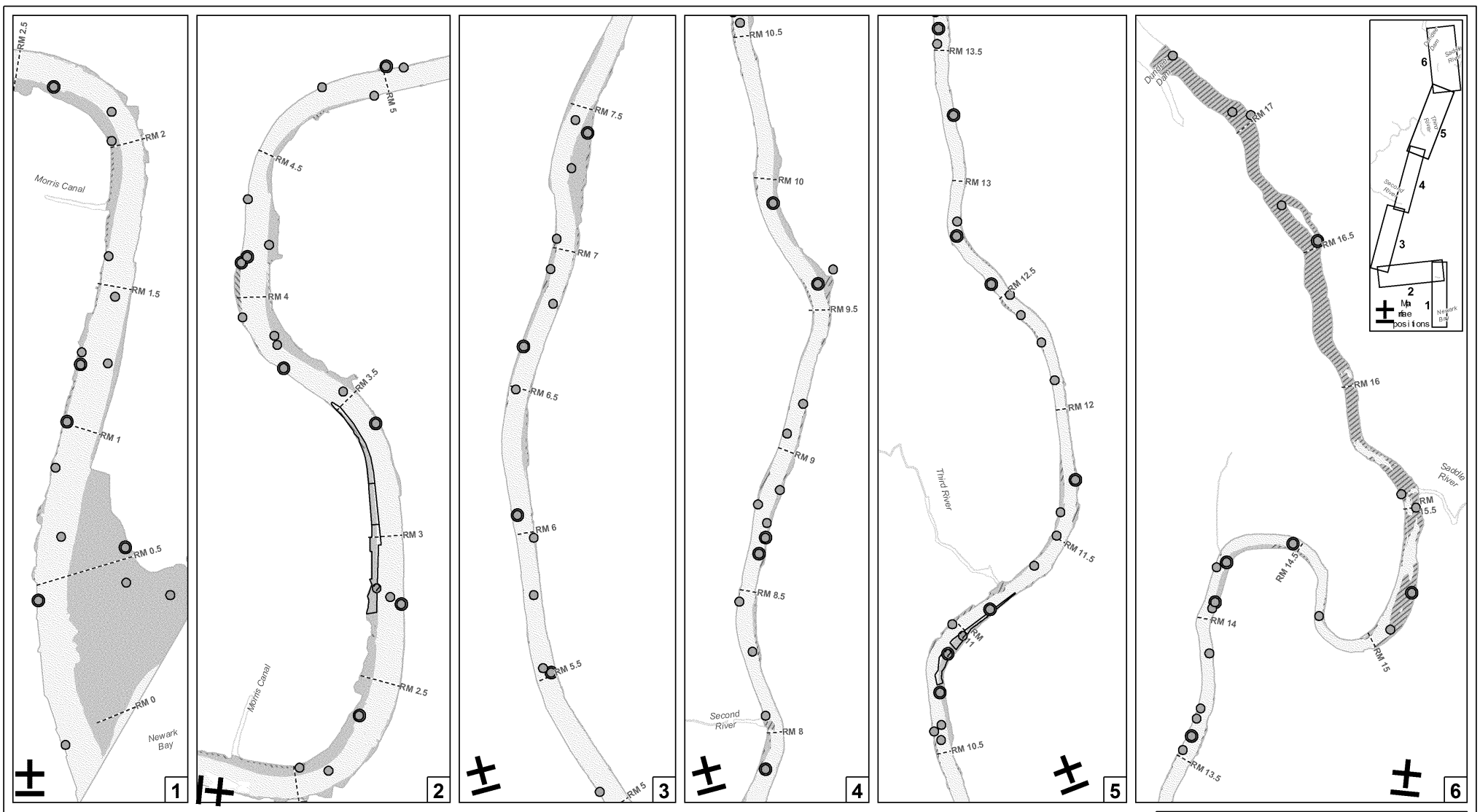

Kilometers

Miles

Benthic community
Benthic community
? Benthic community

River mile
Degraded
Mud
Gravel / shell / fine
ESA

Figure 4-32. LPRSA locations where surface sediment samples were collected during the fall 2009 and spring and summer 2010 benthic invertebrate community surveys

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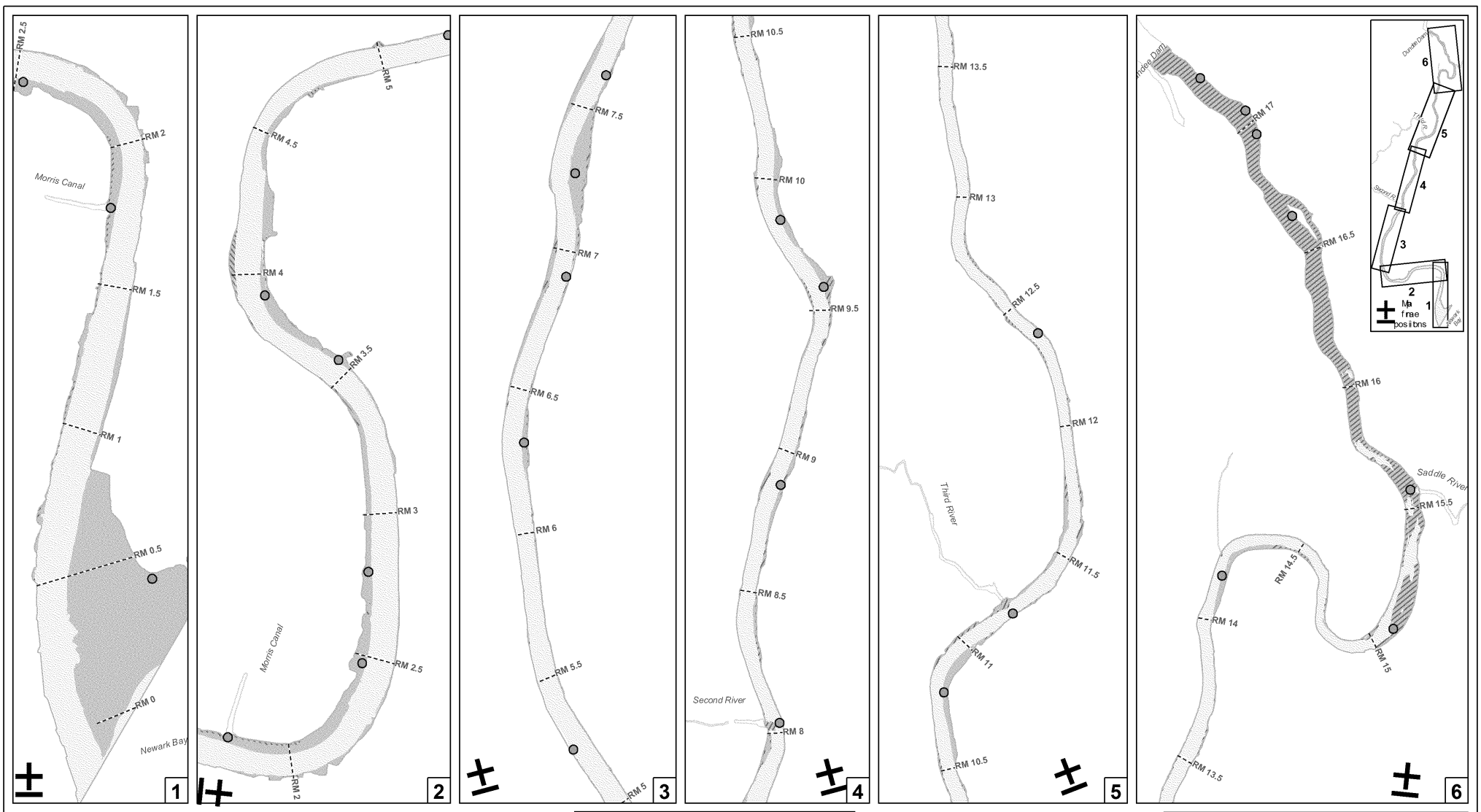

0 5 10 Kilometers

0 2.5 5 Miles

Avian survey location
River mile
Mud flat
Gravel/fine
LPRSA

Some LPRSA survey locations were inaccessible by boat due to shallow water depths, debris, or other obstructions. Avian community analysis was performed for the Passaic River only. Areas not surveyed by boat were surveyed from land (primarily from bridges).

Mud flat surface observations were not collected in areas where vegetation was too dense to see the mud surface. The Meadowlands Environmental Research Institute (MERI) conducted surveys in 2004.

Figure 4-33. LPRSA avian survey locations

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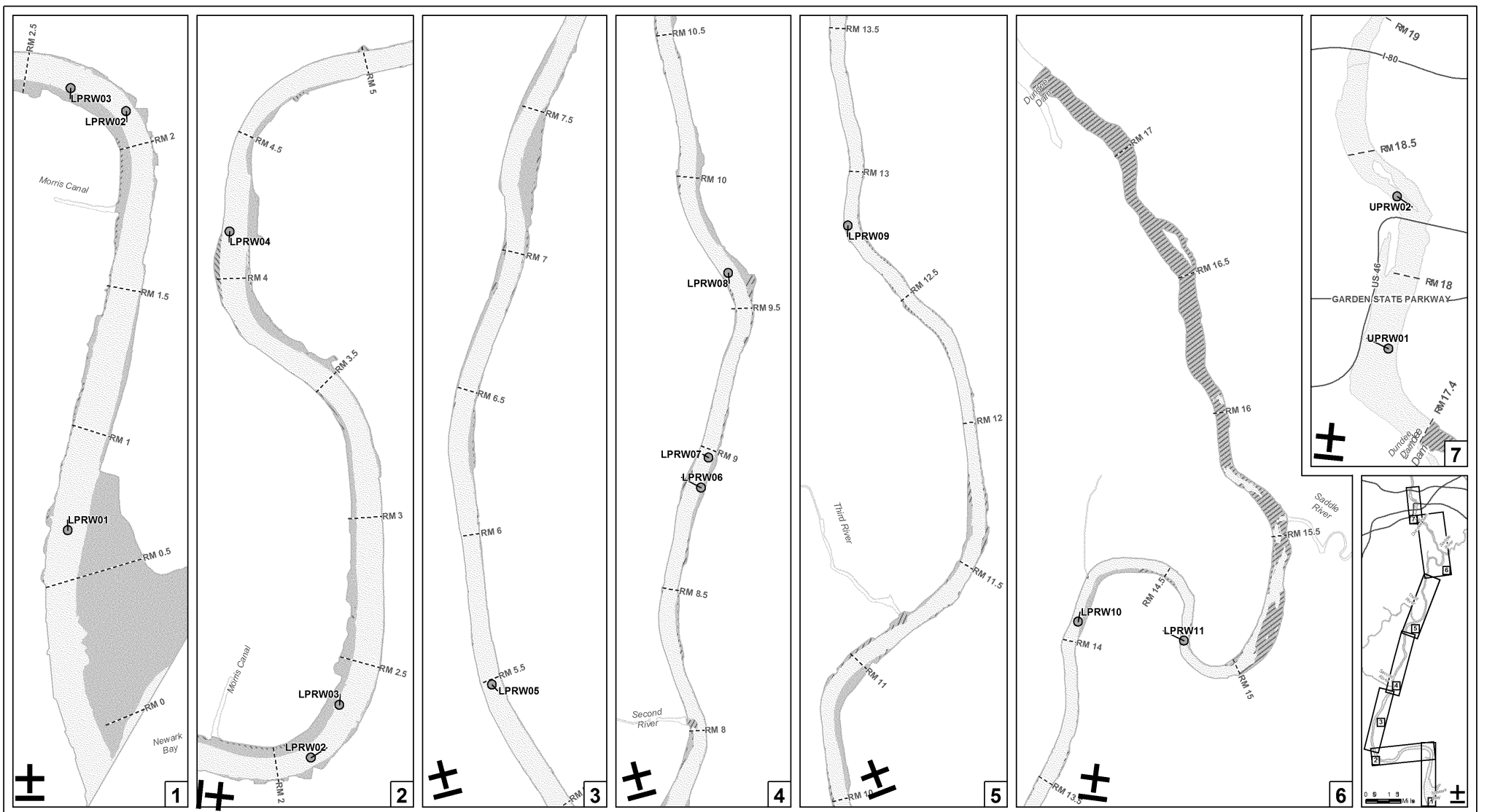

Figure 4-34. LPRSA and above Dundee Dam locations for monitoring dissolved oxygen

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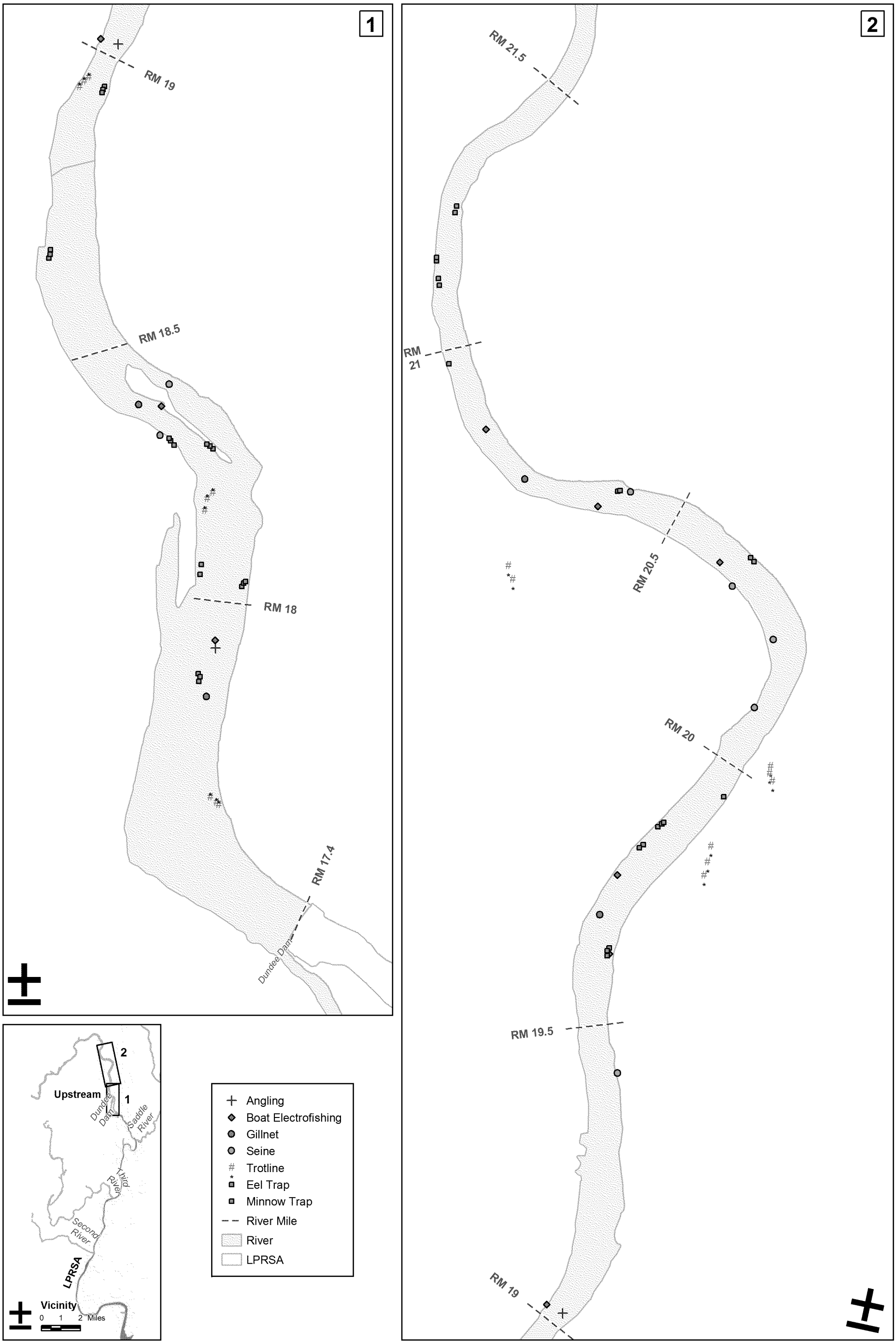

Figure 4-35. Locations where specimens were collected above Dundee Dam during the fall 2012 fish community survey

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Prepared by lindam 6/4/2014; W:\Projects\06-58-01 Passaic RI\Data\GIS\Maps_and_Analysis\BERA\5706_Fish sampling locations above Dundee Dam during the fall 2012 field sampling effort_MTY_20131205.mxd

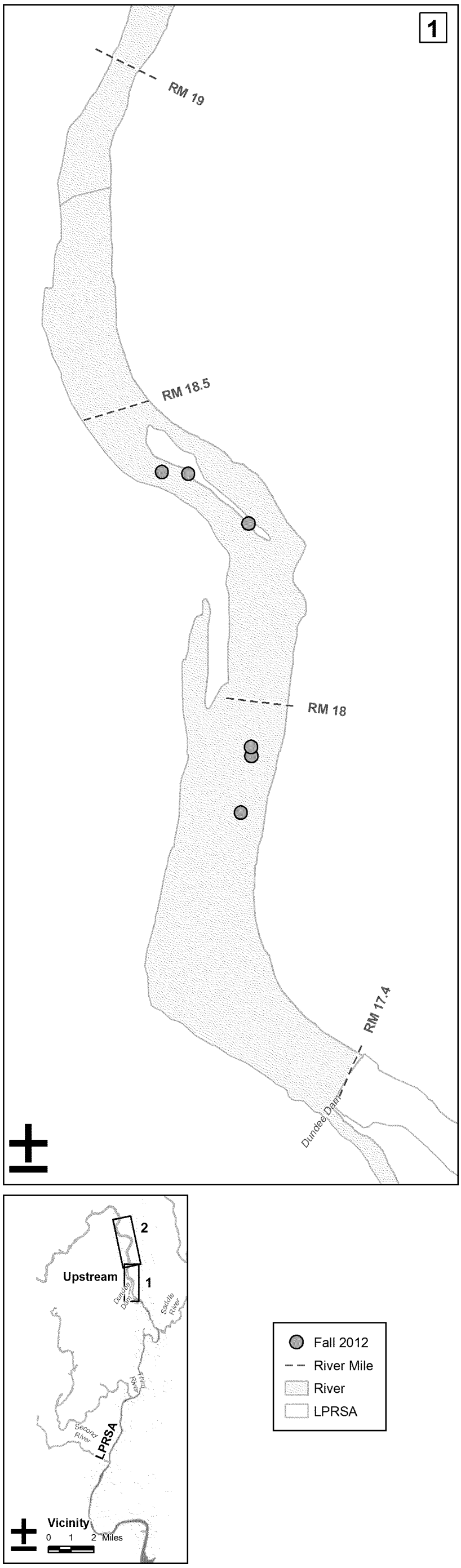

Figure 4-36. Locations where specimens were collected above Dundee Dam for pathology evaluation during the fall 2012 fish community survey

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Data sources: river miles were derived from USGS NHD Streams.

Prepared by lindam 6/4/2014; W:\Projects\06-58-01 Passaic RI\Data\GIS\Maps_and_Analysis\BERA\5707_Fish locations with pathological evaluations Fall 2012_MTY_20131205.mxd

WindWard LLC ENVIRONMENTAL

0 1 2 Kilometers

0 1 2 Miles

± 1993-1998 REMAP

Figure 4-37. Jamaica Bay locations for benthic invertebrate community survey data

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Prepared by lindam 6/5/2014; W:\Projects\06-58-01 Passaic RI\Data\GIS\Maps_and_Analysis\BERA\5779_Jamaica Bay locs for benthic invertebrate community survey data_LSM_20131218.mxd

WindWard LLC ENVIRONMENTAL

0 1 2 Kilometers

0 1 2 Miles

Reference location
- Freshwater
- Estuarine

Figure 4-38. Mullica River and Great Bay locations for benthic invertebrate community survey data

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Prepared by lindam 5/9/2014; W:\Projects\06-58-01 Passaic RI\Data\GIS\Maps_and_Analysis\BERA\5780_Mullica River and Great Bay locations for benthic invertebrate community survey data_LSM)20131218.mxd

4.3 DATA REDUCTION RULES

Data reduction refers to computational methods used to aggregate the data. This section presents data reduction methods for the:

- Calculation of total concentrations (Section 4.3.1)
- TEQ derivation methods (Section 4.3.2)
- Selection of single results when multiple results were reported (Section 4.3.3)
- Calculation of whole-body concentrations from individual tissue types (Section 4.3.4)
- Normalization of data (Section 4.3.5)
- Determination of the number of signification figures for reporting (Section 4.3.6)
- Calculation of upper confidence limits on the mean (UCLs) (Section 4.3.7)

These methods are consistent with the Revised Data Usability Plan (Windward and AECOM [in prep]-a).

4.3.1 Calculated totals

Calculated total concentrations were derived based on the following rules:

- **Rule 1: Non-toxicity-weighted totals (e.g., total PCBs, total PAHs)** – The total concentration was calculated based on the sum of the detected chemical constituents (non-detected chemical constituents were treated as zero).[42] If none of the chemical constituents were detected for a given sample, the total concentration was flagged as non-detected (U-qualified), and represented as the highest reporting limit (RL). If any one of the chemical constituents was not reported, partial totals were calculated and flagged. The use of zero for non-detected chemical constituents and the use of partial totals are addressed in the applicable uncertainty analysis sections of this document.

[42] The treatment of non-detected results as zero is discussed in the uncertainty section.

- **Rule 2: Toxicity-weighted totals (i.e., PCB TEQ and polychlorinated dibenzo-*p*-dioxin/polychlorinated dibenzofuran [PCDD/PCDF] toxic equivalent [TEQ])** – The toxicity-weighted totals for PCBs and PCDDs/PCDFs were calculated by summing each of the detected chemical constituents multiplied by its respective toxic equivalency factor (TEF) (non-detected parameters were treated as zero). If none of the constituent parameters within the toxicity-weighted total were detected, the total was flagged as non-detected (U-qualified), and the highest toxicity-weighted reporting limit was used for the TEQ value. If any one of the constituent parameters was not reported, partial totals were calculated and flagged. The TEFs used to calculate TEQs for PCDDs/PCDFs and dioxin-like PCB congeners were the World Health Organization (WHO) consensus values for fish and birds from Van den Berg et al. (1998). The updated USEPA mammalian TEFs (USEPA 2010) were used to calculate TEQs for PCDDs/PCDFs and dioxin-like PCB congeners for mammals. The use of alternate methods of deriving TEQs (i.e., the use of zero and one-half detection limits for non-detected chemical constituents, and the use of USEPA's TEQ calculator (USEPA 2014) using the Kaplan-Meier method to derive TEQs) is addressed in the applicable uncertainty analysis sections of this document.

Table 4-6 presents the individual chemical constituents of each chemical group and the summation rules. The chemical constituents included in totals were applied to all data that met the acceptability criteria for use in developing risk estimates.

Table 4-6. Chemical groups and summation rules

Chemical Group	Chemical Constituents	Rule[a]
PCBs		
Total PCB congeners[b]	209 PCB congeners	Rule 1
PAHs		
Total HPAHs	benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene,[c] benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3,-c,d)pyrene, and pyrene	Rule 1
Total LPAHs	acenaphthene, acenaphthylene, anthracene, fluorene, naphthalene, and phenanthrene	Rule 1
Total PAHs	acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene,[c] benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3,-c,d)pyrene, naphthalene, phenanthrene, and pyrene	Rule 1
Total benzofluoranthenes	benzo(b)fluoranthene,[c] benzo(k)fluoranthene	Rule 1
Pesticides		
Total chlordanes	alpha-chlordane, gamma-chlordane, oxychlordane, cis-nonachlor, and trans-nonachlor	Rule 1
Total endosulfan	alpha-endosulfan (Endosulfan I), beta-endosulfan (Endosulfan II), and endosulfan sulfate	Rule 1

Table 4-6. Chemical groups and summation rules

Chemical Group	Chemical Constituents	Rule[a]
Total 4,4′-DDx	4,4′-DDD; 4,4′-DDE; 4,4′-DDT	Rule 1
Total 2,4′- and 4,4′-DDD	2,4′-DDD; 4,4′-DDD	Rule 1
Total 2,4′- and 4,4′-DDE	2,4′-DDE; 4,4′-DDE	Rule 1
Total 2,4′- and 4,4′-DDT	2,4′-DDT; 4,4′-DDT	Rule 1
Total DDx	2,4′-DDD; 2,4′-DDE; 2,4′-DDT; 4,4′-DDD; 4,4′-DDE; 4,4′-DDT	Rule 1
TEQ		
PCDD/PCDF TEQ[d]	all 17 2,3,7,8-substituted PCDD and PCDF congeners	Rule 2
PCB TEQ[d]	12 dioxin-like PCB congeners[e]	Rule 2
Total TEQ[d]	all seventeen 2,3,7,8-substituted PCDD and PCDF congeners and 12 dioxin-like PCB congeners[e]	Rule 2

[a] Rule 1: Only detected chemical constituents were used in the sum; non-detects were treated as zero.
Rule 2: The TEQ was calculated by summing the concentration of each congener multiplied by its corresponding TEF value. When the congener concentration was reported as non-detected, the TEF was multiplied by zero.

[b] Total PCBs were based on total PCB congeners (if available). When calculating a PCB congener sum, the concentration associated with a given co-elution was included in the sum only once.

[c] Benzo(j)fluoranthene, benzo(b/j)fluoranthene, and benzo(j/k)fluoranthene were also included in the HPAH, total PAH, and total benzofluoranthene totals when reported.

[d] TEQs were calculated for mammals, birds, and fish for each TEQ type (PCDDs/PCDFs, PCBs, and total).

[e] The 12 dioxin-like congeners are PCB 77, PCB 81, PCB 105, PCB 114, PCB 118, PCB 123, PCB 126, PCB 156, PCB 157, PCB 167, PCB 169, and PCB 189.

DDD – dichlorodiphenyldichloroethane
DDE – dichlorodiphenyldichloroethylene
DDT – dichlorodiphenyltrichloroethane
HPAH – high-molecular-weight polycyclic aromatic hydrocarbon
LPAH – low-molecular-weight polycyclic aromatic hydrocarbon
LPRSA – Lower Passaic River Study Area
PAH – polycyclic aromatic hydrocarbon
PCB – polychlorinated biphenyl
PCDD – polychlorinated dibenzo-*p*-dioxin
PCDF – polychlorinated dibenzofuran
TEF – toxic equivalency factor
TEQ – toxic equivalent
Total 4,4′-DDx – sum of 4,4′-DDD, 4,4′-DDE, and 4,4′-DDT
Total DDx – sum of all six DDT isomers (2,4′-DDD, 4,4-DDD, 2,4′-DDE, 4,4-DDE, 2,4′-DDT, and 4,4′-DDT)

4.3.2 TEQ methodology

As described in Section 4.3.1, the TEQ is a toxicity-weighted value based on the estimated toxicity of various dioxin-like compounds relative to TCDD. Because 2,3,7,8-TCDD is the most toxic of the dioxin-like compounds, each compound is associated with a TEF of less than one, which represents its relative toxicity. The TEQ is the sum of the concentrations of the dioxin-like compounds multiplied by their TEFs. There are a number of uncertainties associated with this methodology, as discussed in (USEPA 2008b):

- A number of relative potencies for each dioxin-like compound, each derived from its own study, were used to derive a consensus value for the TEF. These relative potencies may vary because of uncertainties in the various steps

leading to the determination of value in each study. Such uncertainties include differences in study design and calculation techniques, measurement errors, precision of dose and effects measurements, and natural variability among organisms of the same species in their responses (USEPA 2008b).

- The TEFs are point estimates derived from the individual relative potency studies, and they may range over several orders of magnitude among species within each of the groups (i.e., fish, birds, and mammals). There is uncertainty associated with the method used to aggregate the data used to derive each TEF (USEPA 2008b).
- The TEQ approach assumes that toxicity of each dioxin-like compound is additive. It is possible that synergistic or antagonistic interactions could occur.
- The TEFs used in this BERA include only the PCBs, PDDDs, and PCDF congeners known to elicit responses mediated by the aryl hydrocarbon (AH) receptor.

In addition, recent studies have found that other congeners are more toxic than 2,3,7,8-TCDD, and that the current TEF of 1.0 for two PCDFs (2,3,4,7,8-pentachlorodibenzofuran [PeCDF] and 2,3,7,8-tetrachlorodibenzofuran [TCDF]) may underestimate avian toxicity TEFs (Farmahin et al. 2012; Cohen-Barnhouse et al. 2011; Yang et al. 2010).

4.3.3 Selection of single result when multiple results were reported

When multiple results were reported for a given sample, only one value was used so that every sample was associated with one result per analyte. The rules for selecting the most appropriate result were applied to all data for use in the BERA. The following subsections present the two types of situations in which a single sample result was selected: when multiple analytical methods were used for the analysis of the same chemical in a single sample, and when multiple results were available as a result of quality control (QC) analyses.

4.3.3.1 Multiple analytical results for a single sample

Multiple validated results for a single sample were sometimes reported for specific analytes. When multiple results were reported for a single parameter, the most appropriate result was selected according to the best result rules, as follows:

- Analyte overlap occurred in the SVOC and PAH groups, and the high-resolution results took precedence over the low-resolution results (i.e., high-resolution gas chromatography (HRGC)/high-resolution mass spectrometry [HRMS], HRGC/low-resolution mass spectrometry-selective ion monitoring [SIM], and GC/mass spectrometry [MS]-SIM results took precedence over the low-resolution results [i.e., GC/MS]).

- Analyte overlap occurred in the SVOC and organochlorine pesticide groups (i.e., hexachlorobenzene). The HRGC / HRMS organochlorine results took precedence over the SVOC results.

4.3.3.2 Field duplicates and laboratory replicates

Field duplicates and / or laboratory QC analytical samples might have resulted in more than one analytical result for field-collected samples. QC samples were evaluated as part of the data validation process to ensure that quality assurance (QA) / QC criteria were met. If QC samples were analyzed for a given field sample, only the value of the parent sample was used.

Field duplicate results were averaged with the parent sample result using the following rules:

- If both values were detected, the results were averaged to determine a single result.
- If a constituent was detected in only one sample, the detected value was used.
- If a constituent was not detected in either sample, the result was flagged as a non-detect (U-qualified), and the average of the two RLs was used.

Laboratory replicate results were not used; only the value reported with the parent field sample was used.

4.3.4 Calculation of whole-body tissue concentrations

Results for crab and fish tissue that were analyzed as individual tissue types (i.e., fish fillet, fish carcass, crab muscle and hepatopancreas, and crab carcass) were reconstituted as whole-body fish and crab concentrations based on the fraction of the whole-body mass represented by each tissue type.

Reconstituted whole-body fish tissue concentrations were calculated using the following equation:

$$C_{WB} = C_{fillet} \times f_{fillet} + C_{carcass} \times f_{carcass} \quad \textbf{Equation 4-1}$$

Where:

C_{WB} = estimated whole-body tissue concentration (mg / kg ww)
C_{fillet} = fillet tissue concentration (mg / kg ww)
f_{fillet} = fraction of whole-body weight that is fillet
$C_{carcass}$ = carcass tissue concentration (mg / kg ww)
$f_{carcass}$ = fraction of whole-body weight that is carcass (non-fillet)

Reconstituted whole-body (i.e., edible meat plus hepatopancreas and carcass) crab tissue concentrations were calculated using the following equation:

$$C_{WB} = C_{muscle\_HP} \times f_{muscle\_HP} + C_{carcass} \times f_{carcass} \quad \textbf{Equation 4-2}$$

Where:

C_{WB} = estimated whole-body soft-tissue concentration (mg/kg ww)
$C_{muscle+HP}$ = muscle (edible meat) and hepatopancreas tissue concentration (mg/kg ww)
$f_{muscle+HP}$ = fraction of whole-body weight that is muscle (edible meat) and hepatopancreas
$C_{carcass}$ = carcass tissue concentration (mg/kg ww)
$f_{carcass}$ = fraction of whole-body weight that is carcass (non-muscle, non-hepatopancreas tissue)

For reconstituted whole-body fish or crab concentrations that include a non-detected value for at least one tissue type, the non-detected value(s) were represented in the calculation by one-half the reporting limit. In cases where both tissue types are non-detected values, the final reconstituted whole-body result was flagged as a non-detected result (U-qualified). The uncertainties associated with the treatment of non-detected concentrations in reconstituting whole-body tissue concentrations was evaluated and is presented in the uncertainty analyses of the BERA as appropriate.

4.3.5 Normalization

Both normalized and non-normalized data were considered in the evaluation of sediment data. When applicable (e.g., when sediment criteria are based on OC-normalized values), OC-normalized sediment concentrations were calculated.

Sediment concentrations that were OC-normalized were calculated on a sample-specific basis using the following equation and the TOC data:

$$C_{sed,OC} = \frac{C_{sed,dw}}{f_{oc}} \qquad \textbf{Equation 4-3}$$

Where:

$C_{sed,OC}$ = OC-normalized sediment chemical concentration (mg/kg OC)
$C_{sed,dw}$ = dry-weight sediment chemical concentration (mg/kg)
f_{OC} = fraction organic carbon, dry-weight basis (%TOC/100)

Chemical concentrations in bivalve mollusk (mussel) tissue were normalized by subtracting the final field-exposed mussel concentrations from the control (i.e., Day 0) mussel concentrations to account for non-LPRSA accumulation already present in mussels before they were placed in the LPRSA.[43]

[43] Field-exposed mussel concentrations were normalized to the reporting limit when COI concentrations were below reporting limits in the control (Day 0) mussels.

4.3.6 Significant figures

Tracking of significant figures is important when calculating averages and performing other data summaries. The appropriate number of significant figures associated with specific risk estimates was applied in the last step of each calculation and reflects the least precise value in the calculation (i.e., the lowest number of significant figures).

4.3.7 Calculating UCLs

UCL concentrations used in this BERA to represent EPCs were calculated using USEPA's ProUCL statistical package (Version 4.1.01) (USEPA 2011a) and were derived following USEPA guidance for calculating UCLs for EPCs at hazardous waste sites (2002a). USEPA's ProUCL software can both test the goodness of fit for a given dataset and to calculate central tendency and UCLs of the dataset. The UCL recommended by USEPA's ProUCL software (typically the 95% UCL, but in some cases the 97.5% or even the 99% UCL) was used. Because ProUCL has an option for handling non-detect data (USEPA 2013b), all data (detected and non-detected) were used. For datasets with less than 6 detected samples, a UCL was not calculated, and instead the maximum concentration was used to represent an EPC. In cases where statistically derived UCLs were greater than the maximum detected concentration, the maximum detected concentration was used in place of the UCL concentration to represent the upper-bound value.[44] UCLs used to represent EPCs in this BERA are summarized in Appendix C.

[44] Cases where the maximum concentration was used instead of a UCL are identified in the BERA, when appropriate.